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A METHOD OF DEMONSTRATING LIGHT PHENOMENA

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Science teachers from the time of Newton and probably earlier have sought a convenient method of visually demonstrating the physical phenomena of light and color. The solution has usually been sought in some form of light-pervious medium that would render light rays visible on passing through it. The method most widely used has been the well-known Hartl Optical Disk. Even this is impractical for a class of fair size and too limited in adaptability to cover the wide range of optical effects the resourceful teacher wishes to bring before his class.

The present writer attempted a number of different schemes with varying degrees of success before he finally arrived at a satisfactory solution.

The first attempt was a beam of natural sunlight directed through an aperture cut in the dark shade of the classroom. As the physical laboratory rooms faced the north it was necessary to use a system of mirrors to direct the beam into the room and then up in front of the class in a position where it could be conveniently manipulated by the instructor and easily observed by the class. Not much sooner would this be accomplished than the daily shift of the sun's rays would displace the beam from the desired position. Then, too, the amount of dust in the room was insufficient to render the beam visible enough for satisfactory demonstration. This latter difficulty was partially overcome by the well known practice of creating a local dust in the vicinity

of the light beam by clapping blackboard erasers or some other means, but the effect would not persist long enough to afford more than a fleeting glance of the phenomena.

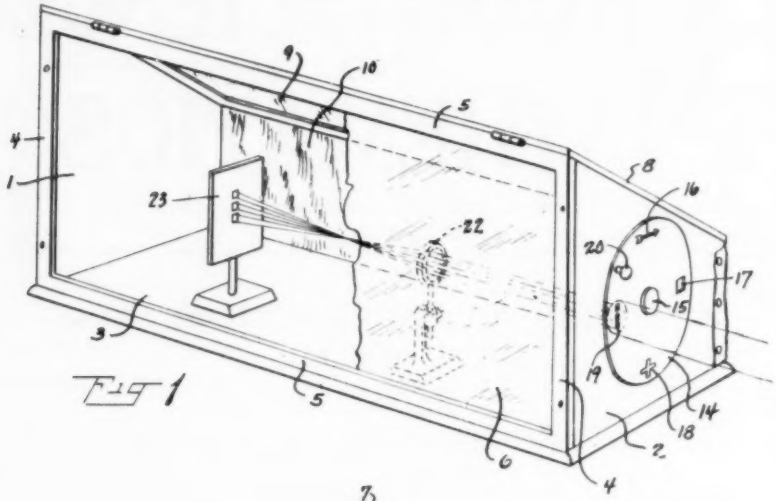


Fig 1

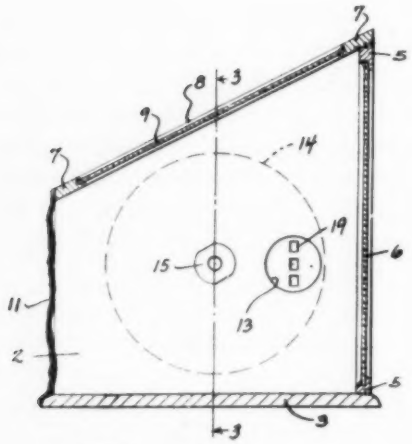


Fig 2

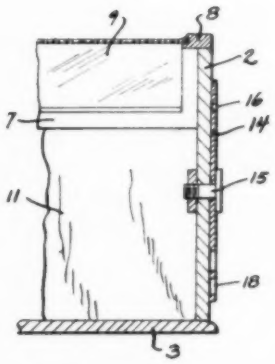


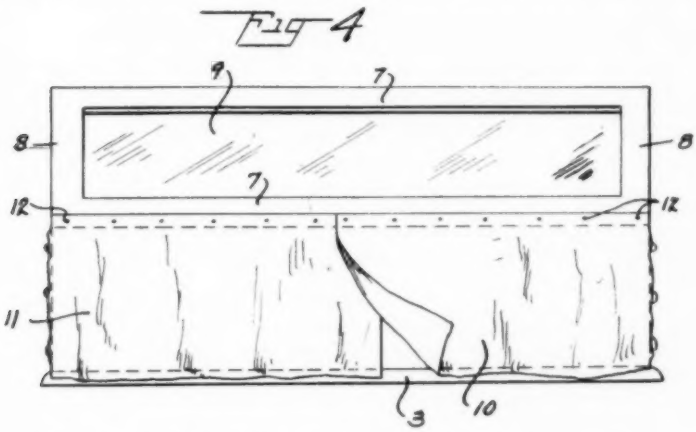
Fig 3

Out of these difficulties was born the idea of filling the entire room with fumes sufficiently dense to render the beam of light visible enough for classroom demonstration. Light from a parallel-beam projector was used to supplant the unruly beam of sunlight. With this arrangement the light-pervious medium was constant and everywhere, and the light beam was fixed and controllable along the top of the demonstration table where it was convenient for both class and instructor.

Notwithstanding the atmospheric discomforts of this arrangement the immediate results were quite overwhelming. They seemed truly quite weird at first. The light beam would lend itself to every conceivable form of optical treatment. All manner of reflection, refraction, diffusion, dispersion, color absorption, filtration and color mixing, the optical effects of lenses and prisms of all kinds, the optical effects of the stereopticon, automobile headlights and telescope combinations were some of the behaviors observed.

It required a very simple thought process then to realize that the atmospheric discomforts might be eliminated without sacrificing any of the essential advantages of the scheme by confining the smoke medium in a small chamber with transparent walls.

The first chamber constructed ten years ago was crude but nonetheless effective. Six years ago the writer had one built to

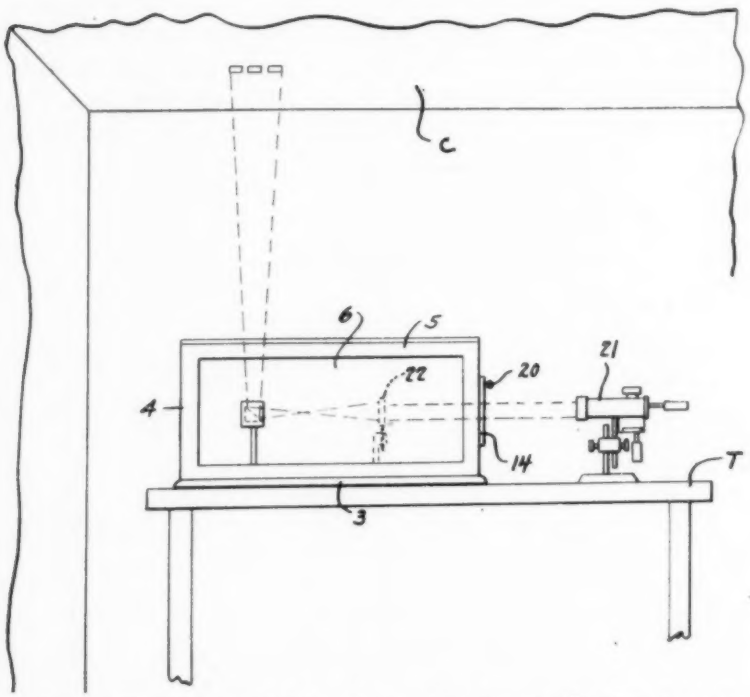


more refined specifications similar to the accompanying cuts. Teachers of science who have had occasion to observe it in use from year to year have expressed so much enthusiasm for it that the writer takes pleasure in bringing it to the attention of others who might wish to use it.

In its present form it embodies a front transparent wall through which the interior of the chamber may be viewed by students from any part of the room. At one end is a circular disk bearing several apertures of different form about its periphery. These may be swung into position to admit the beam of light in any cross section form desired. At one time it may be an arrow to show how a lens causes inversion and again it may be three small parallel beams to show the crossing of rays at the focus

and so forth. The chamber contains a rearwardly inclined transparent top which will permit the projection of light beams upward into the ceiling and allow the instructor at the rear to observe the interior of the chamber. The back wall of the chamber is a black curtain of light-weight material divided at the center, the two parts overlapping several inches. This permits the instructor to reach in and manipulate the apparatus freely throughout the length of the chamber without disturbing the

Fig 5



smoke medium appreciably. Once the chamber is filled to the desired density with either tobacco smoke or punk, it is only necessary to allow a lighted cigarette or punk candle to lay in the chamber to maintain the medium indefinitely while demonstrating.

Such phenomena as the following may be strikingly and conveniently demonstrated: the regular reflection of light beams by plane surfaces; diffused reflection from rough surfaces; the diffusing effect of translucent objects; the effects of converging lenses on parallel rays; the effect of the thickness or radius on

the focal length, and on the size and distances of images; effects of diverging lenses; refracting effect of prisms and other forms and materials; the dispersive effects of prisms; selective absorption of colored transparent objects; selective absorption of opaque colored surfaces; optical effects of combinations of lenses in the stereopticon; optical effects of such combinations as the microscope and telescope; the optical effects of such appliances as the various types of windows used in automobile headlights; the directive effects of different types of lamp shades and reflectors.

This list, of course, does not exhaust the possibilities of the apparatus. Numerous other modifications and adaptations will suggest themselves to the resourceful and ingenious teacher.

A NEW TYPE OF GLASS

Optical glass makers for centuries have been perfecting methods of glass-making which leave the material clear and free from gas bubbles. Now it is found that if the bubbles are left in the glass and intentionally increased in number a highly valuable glass brick building material can be obtained that is light in weight and has super heat-insulating qualities.

Bernard Long of the Saint Gobain Glass Works' laboratory in France described the new bubble glass before the recent International Congress on Glass here.

The material is not termed bubble glass by glass makers but "multicellular" glass because it contains enormous numbers of gas bubbles closely packed together but not touching one another. Between each bubble is a thin layer of glass.

Speaking of sheets made of the new glass, Mr. Long said:

The very small thickness of the divisions between the pores allows them to be easily sawn or drilled without the slightest risk of fracture during either of these operations. It should be noted in particular that nails can penetrate into the multicellular glasses without any difficulty or damage. When driven at an angle of 45 degrees into a vertical partition of fine pored material, they will not give way under a load of several kilograms suspended from them.

The multicellular glasses can be shaped with a rasp, and a slot, groove or notch can be accurately cut in them with the greatest ease.

These new materials appear to be specially suitable for use:

(a) in the form of bricks, for the construction of thin insulating partitions inside buildings.

(b) in the form of slabs of fairly large size, three to four centimeters thick, as heat-insulating linings.

The rough nature of the surface of the bricks as they come from the works appears to be sufficient to insure a good adherence of the plaster and makes their installation an easy matter. If, for any reason, this is considered to be inadequate, a simple scraping will give excellent results.

The acoustical insulation of two and a half inch walls made of the glass material is equivalent to a wall of brick 11 inches thick.

In heat insulating properties bubble glass material two inches thick, when covered with a thin layer of plaster, had the same thermal conductivity as a cork agglomerate coated with plaster on each face.

THE EXHIBIT AS A SUPPLEMENTARY METHOD—CRYSTALLOGRAPHY

By Harold J. Abrahams
Simon Gratz High School, Philadelphia, Pennsylvania

Of necessity many important fields of science must be omitted from the high school curriculum in favor of those which are today considered of primary importance either in themselves or as disciplines. So vast has become the body of fact and theory

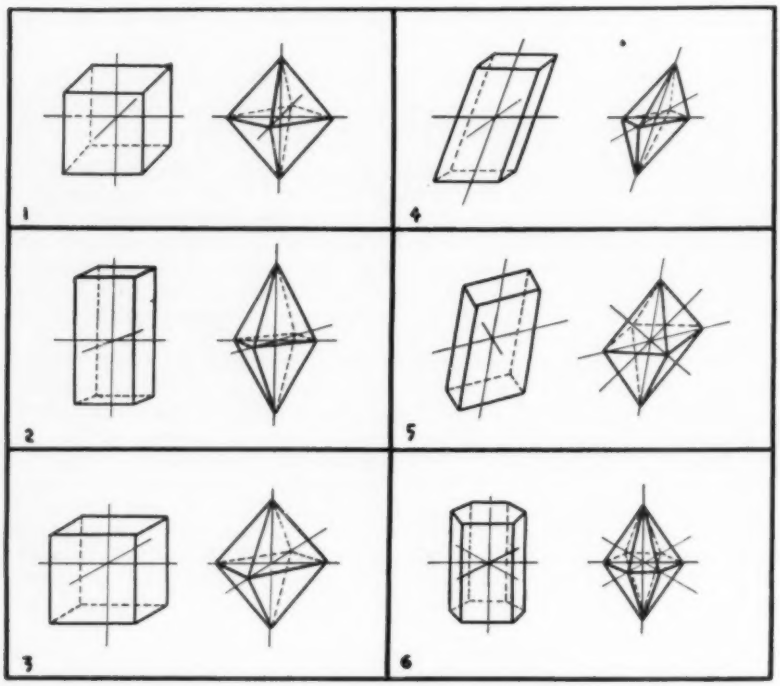
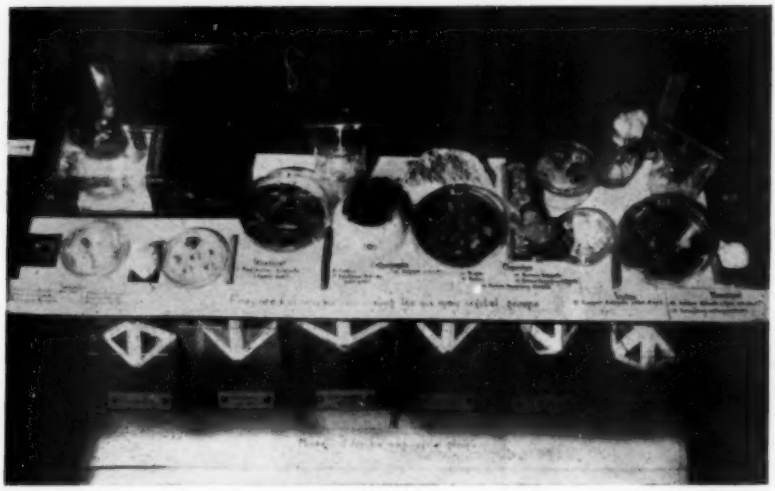


Fig. 1

in those sciences which are included in the high school course that many closely allied fields must be omitted even though they may have intimate contact with the major fields. Not only are they omitted from the curriculum, but the individual sciences find it impossible to include adequate treatment of such correlated fields even though they may be an essential part of the background of more than one of the sciences taught.

A case in point is crystallography, an understanding of which

is of value not only in chemistry, but in physics, biology, and other sciences. A brief discussion of the fundamental principles of crystallography seems entirely omitted nowadays from the various courses in high school science. Potentially, both fascinating and soundly instructive it is slighted by teachers and textbooks alike. Yet frequent reference is made in the classroom to the characteristic shapes of the polymorphus modifications of sulfur, iodine, carbon, ice and many other elements and compounds. The crystallographic terms applied to substances studied in high school chemistry would be far more meaningful against a background provided by at least a minimum knowledge of the simple concepts of this interesting field.



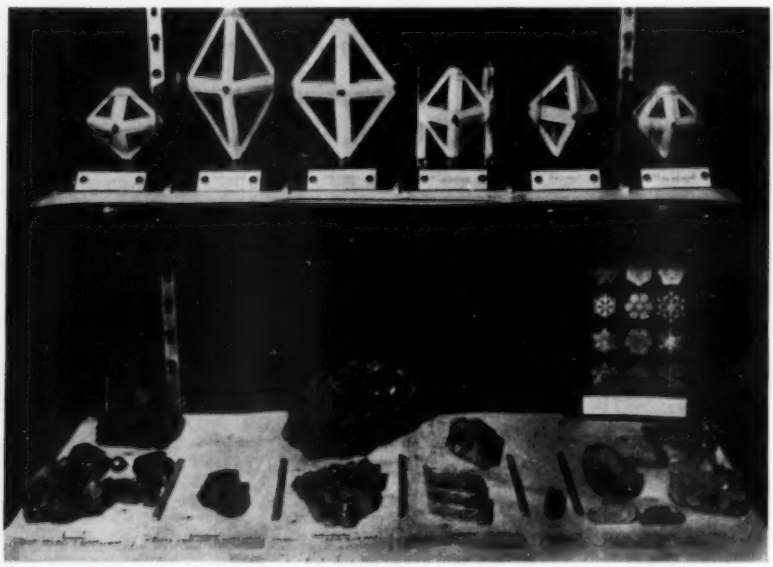
PICTURE 1

A series of exhibits might prove helpful in furnishing a background in certain of these overlapping fields and in partially meeting the restrictions imposed by limited curricula and the rapidly growing body of scientific knowledge. Rotation of such exhibits has the double advantage of including more material and of maintaining greater interest. It would appear that an exhibit which is extended for more than about a month becomes so much a part of the surroundings that it loses much of its value.

A recent exhibit of crystal forms arranged for high school students has served to make many of them conscious of the world of beauty to be found in naturally occurring geometric

forms. Such interest and enthusiasm once aroused may be carried over into the classroom, making students richer in vocabulary, more careful in visual discrimination and more able to recall the crystal form of certain chemicals. It may indeed be that some, at least, of this enrichment will have lasting effects in the direction of improved habits of careful observation, word control and esthetic appreciation.

The exhibit here discussed, consisting of three parts, was arranged in the following manner. Upon the middle shelf of a glass case were placed six celluloid models, representing the six crystal systems. Upon the upper shelf a group of chemicals, chosen



PICTURE 2

for the size and perfection of their crystals, were so arranged as to correspond in crystal systems to the celluloid models immediately below them (upon the middle shelf). A number of minerals, arranged in the same manner on the lower shelf completed the exhibit.

Thus chemicals, model and minerals belonging to the same crystal system, being in the same vertical column, were readily associated by the observer. Another feature of the exhibit was a small magnifier focused upon some sodium chloride and so placed within the case as to be observable from the outside.

Much interest and surprise were expressed by ninth and twelfth-year students alike, the unexpected cubical shape of common salt being striking even though other parts of the exhibit might not be comprehensible.

Above the case was placed a plaque labeling the exhibit as "Nature's Vagaries" and bearing on typewritten sheets the following information, aimed to be both striking and instructive:

One of the most beautiful, though baffling, phenomena in Nature, is the formation of crystals. Men of Science are unable to explain satisfactorily why substances choose one form, rather than another, in which to crystallize. Yet, incomplete as our knowledge of crystallography (the science of crystals) is, it has proved both interesting and useful.

Chemists, physicists, metallurgists, biologists, and others who practice the technical arts and sciences make wide use of a knowledge of crystals. Crystallography even enters into legal trials. There are records, in both fact and fancy, which show that people, incorrectly accused of crimes, have been saved from punishment by the testimony of crystallographers, given in courts of law.

A well known story tells of a man who was about to be convicted for the poisoning of his uncle, in order to inherit the latter's fortune. It was shown in court that the nephew had recently purchased and hidden away some of the same poison of which the uncle died. Although this evidence seemed very conclusive, the defendant was acquitted of the murder charge, entirely because a chemist succeeded in showing that the particles of poison found in the dead uncle's body belonged to a different "crystal group" from those in the bottle. (The same substance sometimes crystallizes in different forms.)

All crystals may be divided into six main groups, depending upon the length of each of their three axes* and the angles at which these intersect each other. The names of these groups and the facts about their axes follow:

1. Isometric, or regular system: Three equal axes, at right angles to each other. Example—cube.
2. Tetragonal system: Two equal axes, and one longer or shorter, all at right angles to each other.
3. Orthorhombic or Rhombic system: Three unequal axes, all at right angles to each other.
4. Monoclinic system: Two axes at right angles and a third perpendicular to one and inclined to the other.
5. Triclinic system: Three axes, all inclined to each other.
6. Hexagonal system: Four axes, three equal axes in the same plane intersecting at angles of 60°, and a fourth at right angles to all these.

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* Axes are imaginary lines, so drawn, that the crystal surfaces are arranged symmetrically about these lines. Opposite ("similar") faces will therefore be parallel to each other, intersecting the respective axes at correspondingly equal distances. The inner and outer models of each pair are so constructed as to possess a common set of axes in every respect, but a host of other geometrical forms which would meet the definitions of a given crystallographic system can be imagined both within and without these celluloid figures. A complete discussion of the measurement of interfacial angles by the reflection goniometer or of how to ascertain the axial angles and ratios would be beyond the scope or purpose of this exhibit, and is left for student "research."

Each of these groups is represented by a celluloid model in this showcase. Note that there are really six pairs of models, each model consisting of one inside another. The purpose of this is to show you that the shape or size of a crystal is relatively unimportant in classifying it. The important thing is the relationship of the axes to each other, with respect to length and angles. Thus you see that two crystals of as widely different appearances as the one inside the other may belong to the same group, because their axes are identical. In these models the axes have been painted red, to make them more visible. They are, however, only imaginary lines.

Many surprises await you, if you will focus a good magnifying glass upon familiar substances. Note, for example, the almost perfect cubes of lowly table salt (sodium chloride) shown under the magnifier in the exhibit. Examine other substances in this way at your first opportunity.

Preparation of the Celluloid Models

The first step in the preparation of these models consisted in making the six sets of axes out of steel rods using stock 3/16 inch in diameter. The rods of each set were fastened together by being forced into suitably drilled holes in a small block of steel. The axes were then painted red, to increase visibility.

Celluloid sheeting, .01 inch in thickness, was then placed over these axes in such manner as to construct octahedrons (eight-sided solid figures, or two pyramids placed base to base. For the hexagonal system the model was, of course, a dodecahedron). The axes were allowed to protrude about $\frac{1}{4}$ of an inch at each end, to permit the next figures to be built up around them. White tape was pasted along each edge of the figures, to accent the shape and increase visibility.

The last step consisted in building hexahedrons around the octahedrons (for the hexagonal system, an octahedron around the dodecahedron.) For this purpose 0.03 inch celluloid was selected, because of its greater rigidity and strength. After perforating with a cork-borer at the correct places, the sides were supported on the axes by passing the latter thru the perforations of the celluloid and then fastening the sides together by means of cellulose tape. The transparency of this kind of tape was ideal for the purpose, as it did not obscure any part of the inside model. Furthermore, opaque tape would add to the already large number of lines and thus cause possible confusion.

Each model (really a pair of models, one inside the other) was then placed upon a black wooden base, with bevelled front edge for suitable label.

Chemicals

The chemicals used in the exhibit were prepared by the usual method of crystallizing upon a thread hung into a hot saturated

solution of the substance in question. Cooling was made to take place very slowly by immersing beakers in hot water. By such means large crystals of copper sulphate, magnesium sulphate and other salts were obtained. Sodium chloride, perfect enough for exhibition purposes can be taken directly from a package of table salt. Alums of various types may be readily prepared by crystallizing from mixtures of hot saturated solutions of the univalent and trivalent sulphates. The only substance in this part of the exhibit which cannot be made in the laboratory is carborundum, but this was used only because it was available, attractive and exemplified a substance made by an unusual method. In choosing chemicals for the exhibit account should be taken of efflorescence and deliquescence on the part of certain salts. In this exhibit efflorescent salts were satisfactorily suspended in small, wide-mouth bottles having a layer of water at the bottom and a plug of cotton or a stopper in the mouth. The iodine was covered with a small, flat, glass jar to prevent sublimation.

CHEMICALS AND MINERALS IN EXHIBIT

System	*Chemicals*	*Minerals*
1. Isometric or Regular	Sodium chloride (rock salt; table salt under magnifier) Potassium bromide Potassium iodide Potassium aluminum sulphate Ammonium aluminum sulphate Ammonium ferric sulphate	Fluorite Galena Garnet Pyrite
2. Tetragonal	Magnesium sulphate	Zircon
3. Orthorhombic or Rhombic	Iodine Sulphur (rhombic)	Sulphur
4. Monoclinic	Sugar Borax Ferrous sulphate Ferrous ammonium sulphate Ferrous ammonium oxalate	 Gypsum Orthoclase
5. Triclinic	Copper sulphate	Rhodonite
6. Hexagonal	Sodium nitrate Carborundum	Quartz Calcite Pictures of snow Hematite

In addition to the advantages indicated above, of the use of exhibits for the presentation of such subjects as the one herein discussed, several other advantages will readily come to mind.

One of these is a proper recognition of the wide variation in the abilities of the student body. Such a method gives opportunity for interested students to enhance their knowledge of a subject not generally treated in class because of the limitations imposed by the presence of a large proportion of less capable students. The lack of ability and interest which would be evidenced by the inferior students would react to the disadvantage of the entire class. For many, perhaps the majority of the students, a classroom treatment of crystallography would be difficult, burdensome, and dull. Illustrated in the manner indicated the facts and concepts are comprehensible, more readily assimilated and not loaded upon a curriculum already burdensome to many students. For certain types of students, a very few to be sure, it can become the starting point for special assignment and "research." Lastly, it may be that "lack of compulsion" may work its subtle psychology upon those who would not otherwise be interested in crystals.

EXPLOSION-PROOF PREPARATIONS APPROVED FOR REMOVING ADHESIVE TAPE

Two preparations for use in removing adhesive tape have been approved by the American Medical Association's council on pharmacy and chemistry as an aftermath of the recent explosion in which two Purdue University football players lost their lives.

With kerosene and gasoline, commonly used to remove adhesive tape, there is always danger that nearby flame or heat may cause an explosion such as killed the two Purdue players, the medical association warns coaches, trainers and the public.

One of the approved substances consists of 98 per cent dichlormethane and has no fire hazard, since it is non-explosive and non-inflammable.

The other is a mixture of 60 per cent carbon tetrachloride and 40 per cent naphtha with a small amount of oil of sassafras. Such a mixture may burn but will not explode under ordinary conditions.

With any preparation of this type, the American Medical Association warns in the forthcoming issue of its Journal, there may be some danger associated with the removal of large quantities of tape in small rooms without proper ventilation. Carbon tetrachloride fumes are poisonous in high concentrations. This, however, is a minor danger and far less hazardous than the use of gasoline anywhere near a source of flame or heat.

The old method of pulling off the adhesive is painful, pulls out hair and may even remove the skin, giving opportunity for secondary infection.

"Coaches and trainers of football teams will do well to equip training quarters with plenty of modern improved solvents so as to eliminate the danger of catastrophe such as that which has thrown a somber atmosphere about the current football season," the medical journal recommends.

—*Science Service*

AN OBJECTIVE LABORATORY TEST IN BIOLOGY

By Bernal R. Weimer
Bethany College, West Virginia

From time to time various teachers have called attention to the fact that most laboratory work in biology has degenerated into a picture-making—and quite often a picture-copying process. Apparently we have lost sight of the fact that the educational function of the laboratory was and is to bring students into actual contact with things which in the field of biology are plants and animals. It is presumed that from the study of these organisms, students will acquire some measure of scientific training and that an opportunity will be offered for the development of a semi-investigative spirit or attitude.

Unfortunately these aims are often buried under a mass of required laboratory drawings and whether intentional or not, the main emphasis is placed on the text "Know the organism's picture" rather than on "Know the organism." It was proposed by the writer in a previous paper (*Proc. W. Va. Acad. Science*, Vol. III, 1929) that in order to focus the attention of the student on the actual organism and provide proper motivation for laboratory study, less emphasis should be placed on drawing, and that students' work be measured by what is known as a practical examination; that is, a test on the actual specimens or materials. However, objections have been raised that there is no time available to administer such tests and that they cannot be worked out conveniently.

In this connection the procedure followed recently in administering a final semester test to a class in General Biology may be of interest. It is very possible that some of the steps and methods used have been applied at some time by other teachers, but the following brief resume is presented with the thought that it might be of interest as a technique for a practical objective test.

The general biology course at Bethany College involves a class of 64 students which, for teaching purposes, is divided into three two-hour laboratory sections. Our examination procedure for testing these groups follows:

At one o'clock in the afternoon of the day specified the first section reported for a testing period of forty minutes. The second section appeared forty minutes later, and the third section forty minutes after that. One ocular of all our microscopes is

equipped with a pointer. (The writer cannot understand why this simple teaching device is not in use in all laboratories where elementary microscopic work is done.) An initial three-minute period was set aside for the student to get his microscope properly adjusted. This period served also to alleviate nervousness and relieve some of the tension involved in examination. At his place each student found a number of prepared microscope slides. Students were then given a series of eleven questions stated somewhat as follows: "Place the tip of the pointer on—(structure)." After an interval of half a minute, each microscope was checked by an assistant or the examiner for correctness. A roll of the students in each section had been previously prepared, and consequently, it was necessary only to make a mark in either the "right" column or the "wrong" column after each inspection. Following this procedure eleven questions were asked.

In the second part of this group testing the students were provided with paper. The examiner exhibited various specimens. To illustrate, among them was a leaf; and pointing to the petiole he asked the students to write after the numeral 1. on his paper the name of the structure. Using this method five questions were asked.

Part II of the examination was given to the students individually. It lasted from three-ten o'clock until five o'clock of the same afternoon. A general schedule was set up following which the students reported by groups to an adjoining room where they were available for examination when called. Moreover, this schedule eliminated congestion and confusion. For this test eight examiners were used. In order to secure uniformity each examiner was given a certain specimen on which he was to ask three questions. All examiners were carefully rehearsed on the method of examination. Thus, one question was to be phrased as follows: "Show me the structure," and the other questions as follows: The examiner points to the structure and says, "What is the name of this structure?" After each question the student was allowed a mental count of ten seconds to answer the question before the next question was asked. Each examiner was supplied with a list of the entire 64 members of the class. The students were then admitted to the laboratory one at a time until all of the eight examiners were busy, and were questioned in turn by each examiner.

Thus, in four hours a class of 64 freshmen were asked forty-

one questions apiece on the laboratory specimens they had studied during the semester, and had been given a test which served:

1. to center the student's attention on the specimen rather than on the drawings,
2. to bring about a better attitude of study in the laboratory,
3. to give the non-artist an equal chance with the artist so far as grades are concerned, and
4. to make for closer attention to actual details of anatomical structure.

The objection may be raised that such a test cannot be used in high school since there would not be a sufficient number of assistants available. The writer believes that any student can be trained to ask three or four questions in a certain manner. In high school it should be possible to select the number of examiners needed from the personnel of the class. These could be examined first and then assist with the examinations of the rest of the group.

An objection may be made that in high school there are only a limited number of microscopes. This part of the test may very readily be dispensed with because, as you will note above, the microscope was necessary for only eleven questions. However, this test would be feasible if one microscope were available provided a micro projector were used whereby the specimen could be projected. The examination could then be given by the teacher pointing to the various regions of the specimen projected on the screen. Moreover, models such as cross section of the stem or of the leaf might serve as substitutes for actual sections on microscope slides.

PAPER-MAKING FACTS

Prof. Clarence E. Libby, head of the department of pulp and paper at the New York State College of Forestry at Syracuse University here, vouches for the following:

1. The wasp was the first paper-making machine, chewing up wood and spreading layers of the pulp over its home. Several modern methods use essentially the same process.
2. A modern paper machine turns out a mile of material each minute.
3. A single issue of a large daily metropolitan paper uses more paper than was used in the whole United States in 1800. The Sunday edition requires the product of 240 acres of pulpwood forests.
4. The newsprint used yearly in the United States would make a sheet 450 feet wide from the earth to the moon.
5. Despite large use the newsprint takes only about 4 per cent of all the wood cut in North America.

NATURE RECREATION IN ST. PAUL

By William Gould Vinal
National Recreation Association

One has but to delve into the origin of nature education in any western city to realize that much of its influence can be traced to New England nature culture. This is especially true in St. Paul. When this was a land of beaver, buffalo, and Sioux, Harriet E. Bishop, a native of Vermont, accepted a call to teach. In 1847 she opened a log cabin school in a 10×12 foot blacksmith shop near the present site of St. Peter and Kellogg Boulevard. There were eight whites amongst her forty children. The Dahkotas complimented her with the name "Good Book Woman." Her education was not limited to books for her keen appreciation of nature frequently appears in her reminiscences, "Floral Homes," published in 1857.

Harriet Bishop came to St. Paul in a canoe paddled by two Indian girls. She relates that although the mosquitoes had a "keen demand of appetite" and "sea-sickness overpowered me," "never the birds sang more sweetly" and "my only wish was that some appreciating friend might share the joys which Nature spread before me. The scenery was delightful."

The teacher concealed the bark roof and rude walls, chinked with mud, with fragrant evergreens. Her description sounds akin to a modern school room. "A friendly hen, unwilling to relinquish her claim, on the ground of pre-occupancy, daily placed a token of her industry in the corner, and made all merry with her loud cackle and abrupt departure. Snakes sometimes obtruded their heads through the floor, rats looked in at the open door and dark faces were continually obscuring the windows. Why should I pine for halls of science and literature, when such glorious privileges were mine." This was certainly a different attitude and reception than was given to Mary's lamb.

Most of Miss Bishop's class were brown children of the forest who still insisted on wrapping themselves in Indian blankets. A few were from the families of pioneers who "tilled the soil, felled the forest, and tended the loom. Society was, indeed, limited, but nature supplied the deficiency. With her I held sweet council, and feasted upon her rich charms. Vigils were prolonged beneath her stately trees, and converse with flowers in their own pure language." In 1849 two other New England spinsters came

to teach and by 1850 district schools were organized with Mr. D. A. J. Baker, an accomplished New Englander, as first teacher.

The St. Paul Female Seminary began in 1858. Hannah Moore Ogden, principal, was, according to the catalog, teacher of natural philosophy, astronomy, geography of the heavens, botany, etc. and Maria Louisa Ogden was a teacher of natural science. It would appear then that nature study was presented from the earliest days.

One cannot review the progress of nature education in St. Paul without reading the autobiography of Christopher C. Andrews (1829–1922). Born in Hillsboro, N. H. he was reared on a farm where, besides ordinary farm animals, he had as playmates sheep, peacocks, and one winter some foxes in one of the horse stalls. His first labor was at the age of four when he dropped pumpkin seeds in every other hill of corn. He was thus destined by his childhood associations to be a champion of the outdoors and more particularly a "Prophet of Forestry."

Beginning in 1869 and for over eight years after, he was minister to Sweden. This is where his interest in forestry was probably awakened. It was his finishing school for important work to come. He attended the first National Forestry Congress April 26, 1882, in Cincinnati and read a paper on "The Necessity for a Forestry School in the United States." It is interesting to note that he was helped in the preparation of his paper by James Russell Lowell.

Christopher C. Andrews framed the first forestry law of the Northwest which was passed in April 1895 for the prevention of forest fires. Andrews was made "Chief Fire Warden." He adopted the New England town system of selectmen firewardens. His title was changed to Forest Commissioner in 1905. Many of the forestry policies granted by Congress were made possible by Andrews. He recommended the Minnesota National Forest, Cass Lake (1902) and the Superior National Forest (1909), and initiated the movement to set aside Burntside Forest (1904) which consists of 20,000 acres of public land for experimental forestry purposes. He earned the title of "Apostle of Forestry."

When a city grows up "within a lifetime" there are innumerable anecdotes and data worth digging up and preserving. David Wild came from Orange, N. J., when his father took up a homestead at Credit River some eighty-two years ago.

The Indians named him "Good Dave." As a boy, "Good Dave" would take his muzzle loader and go out to shoot the passenger pigeon. When these birds migrated south the sky was clouded for days at a time. He can still hear the hum of their wings and he can still see the tubs of wild pigeons ready for cooking, but only in his "mind's eye." He now knows that the passenger pigeons will never come back. As the Indians told him—the day would come when the passenger pigeon would be no more. And so it is with the Minnesota Buffalo. On the publications of the State Division of Forestry he says, "Don't treat your forests as you treated me." And what is true of the passenger pigeon and of the buffalo and of the northern forest is true of all nature. We can no longer assume that these things will last forever with no effort on our part. Nature's gifts to the Gopher State are beyond the average. If we are to be better stewards of what remains than we have of what we had in the past, we must be aroused to a more complete understanding.

The story of nature education in any community is clearly a panorama of cause and effect. One may well ask: Why does St. Paul have a historical museum and a modern zoo and Minneapolis not? Or, why does Minneapolis have a course of study in nature education in the elementary grades with a full time supervisor and St. Paul continues to neglect such procedure with its children? Or, why does neither city have municipal camps like Los Angeles or a winter sports program similar to Lake Placid in New York? Either one would not only be good financing but also an excellent investment in health, morals, and social life.

The answers to many of the existing questions regarding nature education in the North West Territory go back to the beginning days. Although the story parallels the movement in the nation, these changes in St. Paul have taken place within the memory of man. St. Paul has grown up since the Civil War from diverse racial and cultural backgrounds. Within a generation there has been backwoods, urbanization, industrialization, and a return to the outdoors. The passing of the frontier and the rapid exploitation of natural resources has an important message for present day nature planning.

1. *In the Beginning* white pines covered nearly two-thirds of the state. The forests abounded with fur bearing animals and the buffalo inhabited the open places.

2. *Destruction of the Forests.* The decade of 1870–1880 may be

known as the Period of Destruction. The federal government received only $1.25 per acre for the greater part of its timber lands and furthermore it was robbed of millions of acres by the fraudulent use of the homestead laws. We now know that if the forests had been protected and modern methods used, Minnesota could have been a leading lumber state instead of nineteenth. Today the citizens have to pay freight on lumber from the Northwest coast.

3. *Forest Fires.* The débris left from reckless lumbering was an invitation for forest fires. Two of these fires caused the death of nearly one thousand inhabitants. If a foreign army had invaded the state with an equivalent plundering it would have startled the whole world. We now know that the Hinckley and Cloquet horrors could have been prevented by *planned education.*

4. *Sub-Marginal Land.* Through the same policy of trial and error it is now discovered that some sixteen million acres of land, mostly in northern Minnesota, which were cleared for farming are unfit for agriculture. Now that the timber is gone we know that it should have been left as a forest. As a direct result of this ignorance there are seven million acres tax delinquent. With the crumbling of the finances of these northern homes has come the crisis that has had to be met by relief measures. In the meantime the wheat empire has also moved west.

5. *Planned Education.* This chain of events has led to the present chaotic conditions, nationally, as well as within the state. It cannot be overcome by magic or by trusting to luck. The Forestry College was established to enlighten the public. Christopher C. Andrews arose as an Apostle of Forestry. The University of Minnesota is broadening its program. It sponsors an annual historical pageant at Itasca State Park. It has reconstructed a fur-trading post at Jay Cooke Park. The C.C.C. is an army of occupation. The State Department of Conservation, Division of Forestry, has platted numerous lake-front homesites in the North Woods. The State Tourist Bureau advertises the state as a health resort. There is conservation of water ways, game refuges, fish administration, soil erosion control, and land use. Every one of these hark back to days of mismanagement. Can any city afford to neglect to enlighten its future citizens in these great reconstruction plans of the day? Is it any longer safe to neglect outdoor education?

6. *Regional Nature Re-creation Planning.* In the same way

that cause and effect ramifies into the past, so they extend into the future. A city cannot have Youth Hostels until it has hiking trails away from the automobile highways, it cannot have hiking trails until it has metropolitan parks and county parkways, and it evidently cannot have a greater St. Paul park system until it has a regional nature re-creation planning board. The "Adirondacks of Minnesota" cannot function properly until all the citizens realize their responsibility in regard to forest fire prevention, the non-pollution of waterways, the protection of game, and the right use of camps. Youth Hostels are useless in the hands of ignorant youth. Laws do not determine the lives of a new generation but the life of our youth makes it possible to make new conditions. In freeing our youth from long hours of work comes the new obligation of planned re-creation.

Forest Re-creation is an industry. It is the fourth industry of the state. The State Conservation Department estimates that outside tourists leave $82,000,000 in Minnesota annually. Take away the forests, pollute the streams, exterminate the fish and game, and the empire of recreation will follow the empires of lumbering and of wheat. Apply the *laissez faire* policy of the past and the results are inevitable. Have a regional nature re-creation planning commission and gold may still be mined in the North Land.

OFFERINGS OF PAGANS SHOW THE CHANGES IN RELIGIONS

Gifts left by pious pagans at a holy place on the Thorsberg Moor near Kiel have been dug up in huge quantities by archaeologists working under the direction of Dr. Herbert Jankuhn of the Museum of Prehistoric Antiquities, in Kiel. This spot was a sacred place for several centuries, both before and after the beginning of the Christian era, and the succession of gift-types yields a graphic picture of an evolution in the pagan religion in ancient North Germany.

Oldest are large numbers of earthen pots, in which the devotees set out gifts of food—meat, nuts, butter, etc. Then there are considerable numbers of bronze objects, like sword ornaments and cloak pins. Finally the number of gifts becomes much diminished, but their value greatly enhanced, for most of them are of gold. Inscribed gold rings were apparently the favorite offering in this late stage of the cult's development.

It is still difficult to determine what gods were worshipped on the Thorsberg Moor, but the scanty and almost undecipherable runes and occasional images on the rings hint at Thor, the war-god Tiu, and a god named Ull, who presided over winter, skiing, and archery.

A trace of the ancient cult still survives in a market fair regularly held at Nordmark, which is under the auspices of a church instead of the civil authorities as is customary elsewhere.

A COMPARATIVE STUDY OF THE SCHOLARSHIP RECORDS OF STUDENTS WHO MAJOR IN MATHEMATICS

By R. L. Morton, *Ohio University, Athens, Ohio*

and

Leslie Haynes Miller, *Ironton Public Schools*

In the five-year period beginning January 1, 1931, and ending December 31, 1935, 2262 persons received baccalaureate degrees from Ohio University. The authors have abstracted the records of these graduates from the files of the Registrar's office and have analyzed them with special reference to the subject of mathematics.

The 2262 graduates were divided into 29 classes according to their major subjects of interest. These 29 classes are shown in Table I and are ranked according to their mean point-hour ratios. At Ohio University, points are assigned to each semester hour of credit earned as follows: A, 3 points; B, 2 points; C, 1 point; D and F, 0 points. The point-hour ratio is simply the quotient obtained by dividing the total number of points earned by the total number of semester hours carried. For graduation, a minimum of 124 semester hours and 124 points is required.

Table I also reveals the number of majors in each of the 29 subject matter divisions, the standard deviations, the probable errors of the mean point-hour ratios, the differences between the various mean point-hour ratios and the mean point-hour ratio of those who majored in mathematics, the probable errors of these differences, the critical ratios, and the statistical odds that these various groups are superior to or inferior to the group which majored in mathematics. Thus, in the five-year period 36 persons received baccalaureate degrees from Ohio University with majors in Latin. Their mean point-hour ratio is 2.154, a little better than a B average. The standard deviation of this distribution of 36 point-hour ratios is .486 and the probable error of the mean of the 36 point-hour ratios is .055. The difference between the mean point-hour ratios of the Latin and the mathematics groups is .369, the Latin group being superior. The probable error of this difference is .069; hence, the critical ratio, obtained by dividing the difference by the probable error of the difference, is 5.35. The statistical probability that the Latin group is really superior to the mathematics group in the respect here stated is approximately 6500 to 1.

It is the fashion to regard a difference with is sufficiently large to produce a critical ratio of 4.00 or more as significant and to regard differences yielding smaller critical ratios as insignificant. This is obviously an arbitrary standard. When the critical ratio is 4.00 the odds are 285 to 1 that the group found to be superior is really superior. Any one may determine for himself what odds he demands for the interpretation of a difference between two means as significant.

TABLE I

OHIO UNIVERSITY BACCALAUREATE GRADUATES, 1931–1935

Major Group	N	Mean Pt.-Hr. Ratio	Standard Deviation	P.E. of Mean	Diff.	P.E. of Diff.	Critical Ratio	Odds
1. Latin	36	2.154	.486	.055	.369	.069	5.35	6,500 to 1
2. Philosophy	11	1.863	.385	.078	.078	.088	0.89	2.6 to 1
3. French and Spanish	32	1.835	.555	.066	.050	.078	0.64	2.0 to 1
4. Mathematics	63	1.785	.480	.041	Criterion			
5. Geography	24	1.779	.413	.057	.006	.070	0.08	1.1 to 1
6. Psychology	26	1.775	.476	.063	.010	.075	0.13	1.2 to 1
7. English	204	1.746	.462	.022	.039	.047	0.83	2.5 to 1
8. Language and Lit.	48	1.734	.595	.058	.051	.071	0.72	2.2 to 1
9. Art	60	1.723	.426	.037	.062	.055	1.13	3.5 to 1
10. History and Gov't.	58	1.640	.428	.038	.145	.056	2.59	24.8 to 1
11. Biology	71	1.628	.523	.042	.157	.059	2.66	26.5 to 1
12. Secretarial Science	46	1.625	.364	.036	.160	.055	2.91	39 to 1
13. Education	224	1.617	.483	.022	.168	.047	3.57	124 to 1
14. Journalism	44	1.612	.412	.041	.173	.058	2.98	44 to 1
15. Music	86	1.605	.349	.025	.180	.048	3.75	174 to 1
16. Chemistry	65	1.592	.493	.041	.193	.058	3.33	80 to 1
17. Civic Bio. and Botany	19	1.589	.439	.068	.196	.079	2.48	20 to 1
18. History	169	1.560	.478	.025	.225	.048	4.69	1,280 to 1
19. Science	55	1.554	.474	.043	.231	.059	3.92	244 to 1
20. Dramatics and Speech	16	1.548	.493	.083	.237	.093	2.55	22 to 1
21. Pre-Medic	20	1.543	.396	.060	.242	.073	3.32	79 to 1
22. Sociology	35	1.529	.417	.048	.256	.063	4.06	323 to 1
23. Engineering & Physics	98	1.522	.385	.026	.263	.049	5.37	6,800 to 1
24. Home Economics	99	1.519	.398	.027	.266	.049	5.43	8,000 to 1
25. Economics	50	1.511	.523	.050	.274	.065	4.22	451 to 1
26. Commerce	289	1.426	.414	.016	.359	.044	8.16	53,000,000 to 1
27. Industrial Arts	117	1.406	.328	.020	.379	.046	8.24	73,000,000 to 1
28. Physical Education	182	1.315	.352	.018	.470	.045	10.44	Practical certainty
29. Agriculture	15	1.285	.290	.051	.500	.065	7.69	9,400,000 to 1
Total	2,262	1.574	.465	.007	.211	.042	5.02	2,800 to 1

If we apply as a criterion of significance a critical ratio of 4.00, we find that Latin is the only subject the majors in which rank significantly higher in scholarship, as measured by the point-hour ratio, than do the majors in mathematics. The philosophy group and the French and Spanish group also rank

higher but not significantly so. Indeed, no one would contend that the differences between the point-hour ratios of these groups and that of the mathematics group are significant differences. Also, there are several groups which rank lower than the mathematics group but not significantly lower. This is particularly true of the groups majoring in geography, psychology, English, language and literature, and art.

Continuing the application of the same criterion, we find that the groups in history, sociology, engineering and physics, home economics, economics, commerce, industrial arts, physical education, and agriculture are significantly lower in scholarship, as here measured, than is the group in mathematics. Of particular significance are the differences between the groups in agriculture, commerce, industrial arts, and physical education and the group in mathematics. There is little doubt, if current conditions continue to prevail, that those majoring in mathematics will in future years rank higher scholastically, on the average, than will those majoring in any one of these four subject matter fields.

Differences which are impressive but which fail to satisfy the criterion of significance here employed are found for the groups in science, music, education, and chemistry and the pre-medic group, for all of which critical ratios greater than 3.00 are found. Lesser but still fairly large differences are found for those majoring in journalism, secretarial science, biology, history and government, dramatics and speech, and civic biology and botany, the odds for the superiority of mathematics for the least of these being 20 to 1.

As indicated by the last line of the table, the odds are 2800 to 1 that those who major in mathematics are superior scholastically to all other graduates.

Mathematics is not a popular subject. In the five-year period reviewed here only 63 persons graduated with majors in this subject. This is less than three per cent of the total number of baccalaureate graduates. But those who elect mathematics as a major are, generally speaking, able to make relatively high scholastic marks.

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

A STUDY OF THREE METHODS OF TEACHING SCIENCE WITH CLASSROOM FILMS

By W. J. Hall
North Division High School
Milwaukee, Wis.

The development of classroom motion picture equipment to a point where practically any school system can afford its purchase, and the availability of numerous, carefully prepared teaching films at low cost or rental has made the use of films in the classroom a practical and valuable aid. As a result much has been written on the methods of using classroom films and on their value. Many statements concerning the value of classroom films have failed to include any supporting data. When later research indicates an element of exaggeration and a lack of scientific basis for given statements, such statements tend to reduce rather than build up a following for a cause.

Since the development of methods for use of classroom films is in its infancy there is a distinct need for much educational research before accepting any method. While the instructor is concerned with accomplishing results, with getting things done, it is clear he must not neglect the "knowing" side of the field of pedagogy.

The Problem

Having developed a method for the teaching of classroom films the writer undertook a study to determine its value, if any, when compared with two other methods employed by teachers using classroom films. This study then resolved itself into the problem of which of the three methods of teaching with classroom films produced the most effective retention of knowledge.

If one of the three methods should prove superior to the others, a study of this nature if made on a large enough scale would be the basis for discarding the inferior methods in favor of the better method. It is only through scientific research that teachers can be certain of the value of any method when compared with another.

The Methods Compared

The methods compared were designated as methods A, B and C. Briefly stated they were:

METHOD A:

At the beginning of the class period students are informed that a film supplementing present classwork is to be given and that a test will follow the film. They are asked to be on the alert for important information shown in the film, especially for such subject matter as has previously been discussed in class. Students are urged to ask questions or to request the re-showing of parts not clear during the showing of the film. Students are free to take down notes if they so desire. The film is then projected and at the discretion of the instructor comment is made, still pictures (especially of animated diagrams) are shown, and the machine is stopped, speeded over unessential material or slowed down for important detail. Blackboard diagrams to supplement the film are sometimes used. Following the projecting of the film a class discussion emphasizing important principles, guided by the instructor takes place. A completion test on a prepared slide, is then projected on the screen. The students write their answers, exchange and mark papers. While marking papers students are given opportunity to question any answer. This activity often starts worth-while discussion between students holding conflicting viewpoints.

METHOD B:

The same procedure is followed as for method A with the exception that no test is given.

METHOD C:

The same procedure is followed as for method A with the exception that the test questions are projected on the screen at the beginning of the class period for a pre-reading and remain on the screen below the projected film throughout the showing of the film. Students are requested to write the answers as soon as they know them. Care is taken in preparing questions to see that they have the same sequence as the film and all thought questions are placed at the end of the list.

An effort was made to have only one varying factor in each method. Method A—a test following projection; method B—no test; and method C—a test during projection. All of the films were selected on the basis of their relation to the topic being studied, and special construction for classroom use. The films used were selected from the "Eastman Classroom Films" and "Pathé Science Series" in the general field of geology.

The names of the films given in the order used are:

1. Work of Running Water
2. Work of Underground Water
3. Sculpturing of Land by Rivers
4. Volcanoes
5. Earthquakes
6. Soil

The Subjects

The subjects were the students of three second-semester general science classes in the first year of high school. An effort was made to equalize the three groups so as to use the equivalent-groups method.[1] This proved impractical since it was impossible to obtain matched groups of more than twelve subjects each. As a result the rotation method[2] was decided upon. In this procedure methods A, B and C were used in rotation in each of the three classes. This eliminated the necessity of equalizing the groups and minimized the effect of "carry over." Six films were used, each class seeing each film once and using two of the films for each method.

A pretest was given two days previous to the showing of each film. The same test was used in methods A and C as testing was a part of the method. Two weeks later the same test was given in all classes to measure retention. The difference between the pretest mark and the final retention test mark was taken as the change produced by each of the three methods.

After showing the first three films according to this procedure it seemed possible that there was an advantage in methods A and C due to taking the test on the day of the projection while method B did not provide for the use of the test questions between the pretest and the final retention test. Therefore the last three films were shown with the added feature of a test on the day following projection in each of the three methods. Also, due to a vacation period interfering, the final retention tests were given four weeks after projection instead of two weeks, for the last three films. As a result the study is in two parts: 1, results for the first three films and 2, results for the last three films.

Results

The data obtained for the six films are shown in Table I. This table includes the means, standard deviations, and probable errors of the means for three different comparisons:

1. The actual marks on the final retention tests.

[1,2] H. H. Abelson, *The Art of Educational Research* (World Book Company, 1933) page 142.

2. The changes from the pretest to the final test.
3. The percentage of possible change from the pretest to the final test.

The statistical constants in each case were obtained from a distribution of individual scores.

TABLE I

MEANS, STANDARD DEVIATIONS AND PROBABLE ERRORS OF THE MEANS OF THE MARKS ON FINAL RETENTION TESTS, CHANGES FROM PRETEST TO FINAL RETENTION TEST AND PERCENTAGE OF POSSIBLE CHANGE, FOR THE THREE METHODS COMPARED

	First 3 Films				Second 3 Films		
Method	M	*SD*	PEm	Method	M	SD	PEm
			Final Retention Test				
A	74.78	15.83	1.24	A	73.50	17.85	1.49
B	61.40	16.35	1.28	B	62.19	21.10	1.77
C	79.58	14.65	1.45	C	75.80	14.78	1.23
			Changes from Pretest to Final Retention Test				
A	55.00	17.70	1.39	A	42.47	16.75	1.40
B	39.24	17.75	1.39	B	33.53	14.19	1.19
C	58.37	17.85	1.40	C	49.80	17.15	1.43
			Percentage of Possible Change				
A	68.10	19.75	1.55	A	66.20	22.50	1.88
B	49.24	19.40	1.52	B	49.65	22.15	1.85
C	71.40	19.55	1.53	C	67.43	21.55	1.80

The purpose of this study was to discover any possible advantage in one of the methods being compared. Table I shows in every case that method C is slightly superior to method A and method A is much superior to method B. This indicates that methods using tests when showing films are superior to the showing of a film without a test. The results of the final retention test for instance show that the average mark when methods A and C were used are 14.12 points higher than when method B was used.

For these findings to be significant the difference between any two means compared should be greater than four times the probable error of the difference between the two means. Table II makes comparisons of the three methods showing the difference of the means, the probable errors of the difference between the two means and the ratio between the difference of the two means and the probable errors of the difference between the two means. Where this ratio is not at least four there is no significant difference between the two methods being compared. The method found to be superior is listed first, thus in A and B, method A was found superior to method B.

TABLE II

DIFFERENCE BETWEEN MEANS, PROBABLE ERROR OF THE DIFFERENCE BETWEEN THE TWO MEANS AND THE RATIO OF THE DIFFERENCE BETWEEN THE MEANS TO THE PROBABLE ERROR OF THE DIFFERENCE BETWEEN THE TWO MEANS; OF THE METHODS COMPARED

First 3 Films				Second 3 Films			
Methods Compared	M_1-M_2	PEm_1-m_2	Ratio	Methods Compared	M_1-M_2	PEm_1-m_2	Ratio
Final Retention Test							
A & B	13.38	1.78	7.51	A & B	11.31	2.31	4.89
C & B	18.18	1.72	10.57	C & B	12.90	2.15	6.00
C & A	4.80	1.69	2.83	C & A	2.30	1.93	1.19
Changes from Pretest to Final Retention Test							
A & B	15.76	1.97	8.00	A & B	8.94	1.83	4.88
C & B	19.13	1.97	9.71	C & B	16.27	1.86	8.74
C & A	3.37	1.97	1.71	C & A	7.33	2.00	3.66
Percentage of Possible Change							
A & B	18.86	2.17	8.69	A & B	16.55	2.62	6.31
C & B	22.16	2.15	10.30	C & B	17.78	2.58	6.89
C & A	3.3	2.17	1.52	C & A	1.23	2.59	.47

Table II shows that there is no significant difference between methods C and A; it shows in every case that there is a significant advantage in using method A or C in preference to method B.

CONCLUSION

Due to the fact that the writer developed method C it is possible that the advantage it indicates over method A, though not significant, is due to unintentional manerisms favoring it, caused by natural prejudice. Every effort was made however to keep all of the factors equal except the ones being compared.

The greatest value of this study is that it is suggestive. The results are very limited in their validity because of the small number of subjects. (There were 74 cases for the first three films and 65 cases for the second three films.) The uniformity of the results is however interesting. If this study were applied to a large enough sampling with the same results, it is reasonable to assume that students would retain more from films if tests accompany the showing of films than if no tests are given.

In the writer's limited observation the experience has been that a large majority of the teachers using classroom films do so

without the use of any tests at the time of showing films. If this is a general condition can it be justified?

THE BIOLOGY CLUB FOR INDIVIDUALIZED INSTRUCTION

By Frieda Lichtman
Julia Richman High School, New York, New York

The primary objective of secondary school education is to prepare Youth for a healthful and efficient life. Individualized instruction in the various fields of science teaching should achieve this end. In the past, only the scientific-minded enrolled in science courses.

In recent years, however, compulsory education and progressive trends have presented new problems in the technique of science instruction. The introduction of the general science course into the curriculum was one of the solutions. Increased registration in the field of special sciences followed.

The teachers of biology in classes with large registers must adapt courses of study and methods to the individual's needs. The biology club serves as an excellent device for this purpose.

Such a group was organized at the Julia Richman High School. The pupils' biological experience was enriched by means of a diversified program. The faculty sponsor was thus able to discover and encourage individual interests and aptitudes, with gratifying results.

Keen interest was manifested in the preparation of microscope slides and in studies employing the microscope. Members of the club were also enthusiastic about animal dissection and other laboratory techniques. Exploratory field trips led to many discoveries. Appreciation of the local environment was promoted by visits to parks, to the Zoological and Botanical Gardens, and to scientific institutions, e.g., The American Museum of Natural History, Hayden Planetarium, and Museum of Science and Industry. The most stimulating sessions of the club proved to be visits to a hospital and to a research biological laboratory. Demonstrations by gracious members of the staff at these institutions opened up new scientific vistas to the pupils. Favorable reactions were evident by the increased attendance at lectures on science, new affiliations with junior science organizations, and the reading of scientific literature. Conversation and activities reflected new interests. It was obvious that initiative had also been fostered by individualized instruction, for even the timid suggested problems for scientific investigation.

Club programs devoted to experimentation proved popular. Among the subjects which claimed great interest were reflex responses in the pithed frog and behavior of microscopic organisms under variable conditions. A group project, the breeding of rats in the study of a problem in heredity, maintained their interest for months.

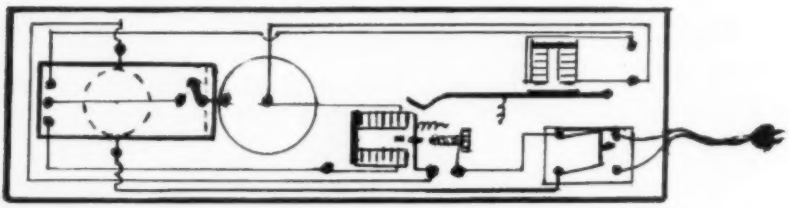
The biology club proved valuable for its vocational, avocational, and cultural contributions. It also encouraged the development of scientific attitudes and habits of thinking. Since these are the fundamental objectives of secondary education, I believe that the organization of a biology club is an effective device for individualized instruction and an aid in the preparation of our Youth for efficient living.

PORTABLE UNITS FOR PHYSICS DEMONSTRATION

By F. W. Moody,
Cleveland High School, St. Louis, Mo.

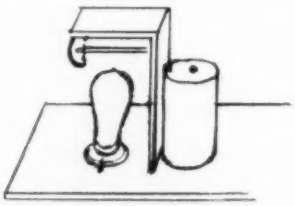
Using the physics classroom for two grades of work and for daily meetings of an advisory group has suggested for demonstration, portable types of assemblies, on the order of the pulley assembly, so mounted that they may be quickly returned to the cases as assembled units. Some of these may be of interest to other teachers of Physics.

A thermostat model never roused very much class interest until it could be seen in operation so we have one mounted



Thermostat Unit No. 1

Thermostat model mounted above a lamp which it alternately turns on and off. The time interval may be regulated by adjustment of the contact points.



Relief mounting of lamp and thermostat No. 1-b

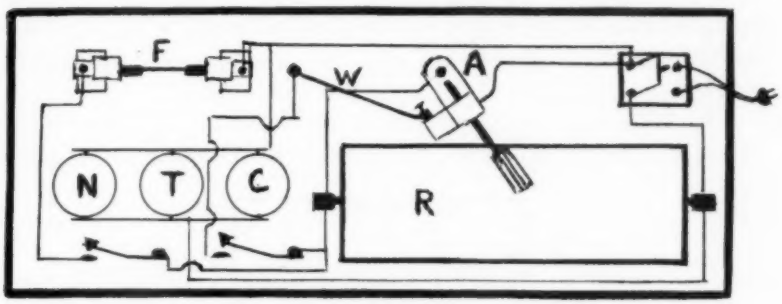
above an electric light bulb where the heat from the lamp works the thermostat, No. 1 and No. 1-b.

The current supplied the lamp is too strong for the thermostat and would arc the contacts so we have a dry cell in series with the thermostat and an old relay which turns on the lamp current. Then an old bell, with gong and interrupter removed, is so mounted that its armature checks the armature of the relay, holding the circuit open until the second contact on the

thermostat closes the bell circuit, removing the check from the relay armature.

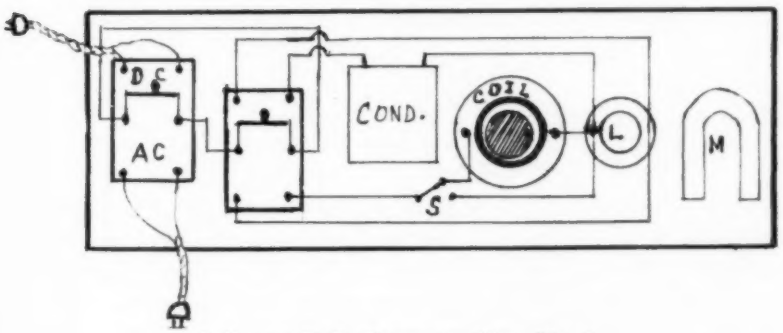
These are compactly mounted on a board occupying only a small space in the case. There is a switch on the cell circuit, and a lamp cord with switch connected to the lamp circuit and ready to plug in. It is a simple thing taking only a few minutes to show it and would not warrant wasting much time to get it working.

The lighting and heating unit No. 2 has a resistance in series



LIGHTING AND HEATING UNIT No. 2

F—Fuse W—Wire to show heating effect
A—Arc N—Neon Lamp T—Tungsten Lamp
C—Carbon Lamp R—Resistance.



A.C. AND D.C. CONTRAST UNIT No. 3

Board with lamp mounted so that it may be thrown in series with a condenser, or coil, or directly on the line voltage of either A.C. or D.C. source.

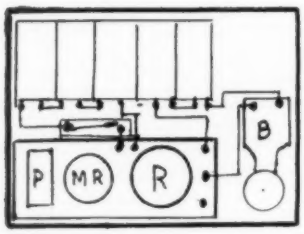
with a small arc lamp, and these are in parallel with three lamp sockets for neon, tungsten, and carbon lamps. These illustrate the different principles of obtaining light from electricity.

By pressing a key the resistance is placed in series with a six inch piece of German silver wire which glows red in about two

seconds demonstrating the heating effect. A second key when pressed throws the resistance in series with a link fuse held in place by spring clips. The strong current from the resistance quickly blows the fuse showing how it functions.

No. 3 is another useful unit for demonstrating the contrast in the action of the alternating and direct current. It has a lamp which can be thrown in series with a condenser, or with a coil with removable core. There is a switch by which the coil may be cut out giving the full voltage to the lamp so that the contrast in the vibratory action of a carbon filament may be shown when the lamp is supplied with either of the two types of current, and when a strong magnet is placed over the lamp.

The Weston photoelectric cell and Photronic relay assembly No. 4 has been placed on a larger board, the miniature relay

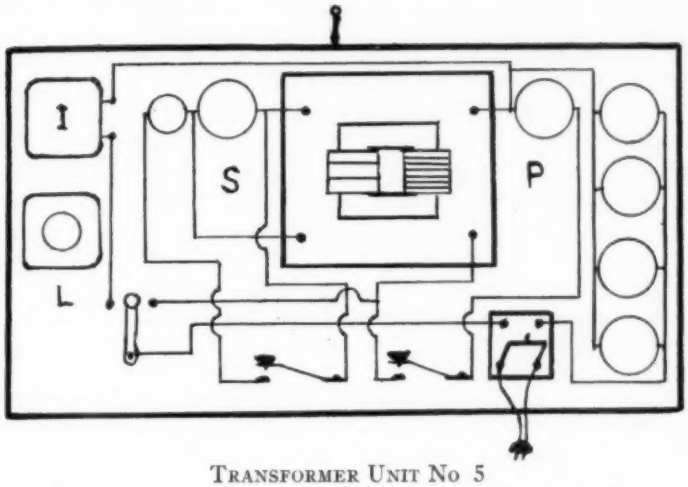


PHOTOELECTRIC CELL UNIT No. 4
Weston Photronic Relay Model 607 comprising photoelectric cell, P miniature relay, MR and relay, R mounted on board and connected to switch, batteries, and bell.

circuit connected through a switch to an operating battery of dry cells. A second battery and bell, connected to the large relay completes the assembly. The whole thing is portable and ready when the switch is thrown, to operate either when the cell is shaded or when a light is flashed on it.

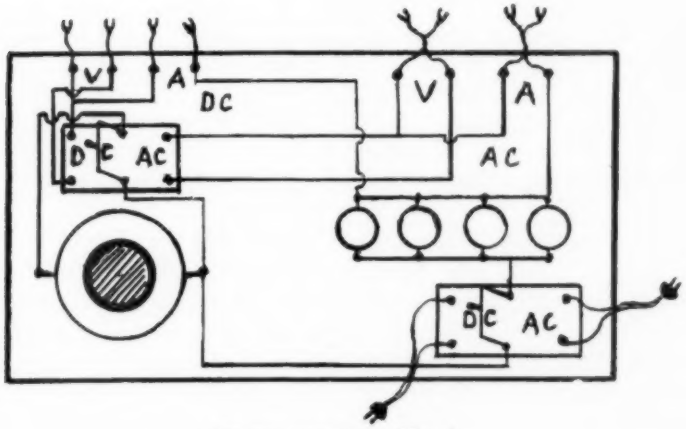
The transformer unit No. 5 has a lamp resistance controlling the current in the primary circuit. It is connected in as a step down transformer. There is a 110 volt lamp connected across the secondary and by closing a contact key a similar lamp may be connected across the primary, so that the difference in voltage may be judged from the difference in brightness of the two lamps. A second contact key connects the secondary to a 15-volt lamp which then glows with normal brightness.

A three point switch cuts out the transformer and turns the current on coil I containing a soft iron core, part of an old transformer. Another similar portable coil, L, with a 15-volt lamp mounted on top of it and connected to it, glows brightly



TRANSFORMER UNIT No 5

P—Primary S—Secondary I—Induction coil
L—Portable coil



IMPEDANCE UNIT No. 6

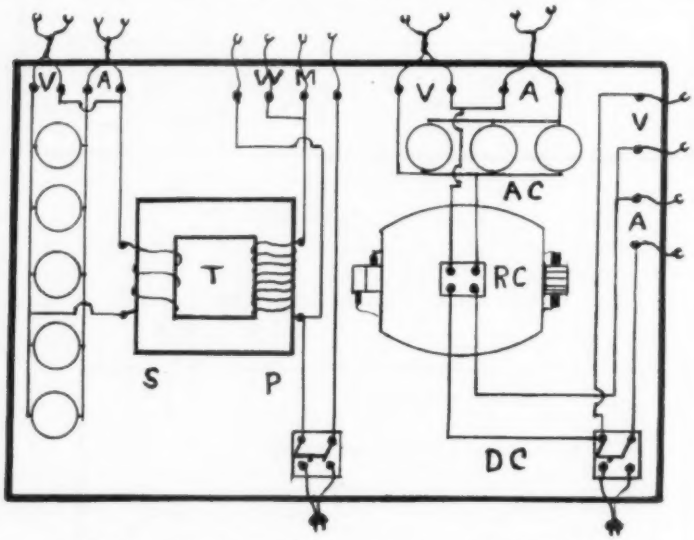
when placed on top of I. The lamp begins to glow even when the two coils are a few inches apart or when one stands beside the other. Coil L is also part of an old transformer. The point about the whole thing is the quickness with which it can be shown.

The impedance unit, No. 6, more particularly for experi-

mental use, is ready when the switches are thrown to the D.C. side, to show readings of voltage and current in the coil, from which its resistance is determined. When thrown to the A.C. side it is set to show the A.C. readings of voltage and amperage from which the impedance is calculated. The lamps control the current.

The transformer and rotary converter unit, No. 7, is a convenient and ready hook-up for demonstration or laboratory experimentation.

The converter changes D.C. to A.C. and is ready to connect the ammeters and voltmeters for an efficiency test. The transformer is connected up as a step-down transformer. A watt-



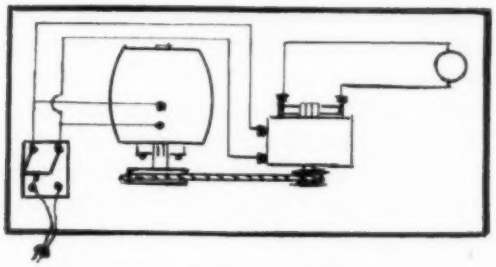
TRANSFORMER AND ROTARY CONVERTER UNIT NO. 7

meter is used on the primary but in the secondary non-inductive circuit, the voltmeter and ammeter are used. From these readings the efficiency may be determined. 150-watt lamps are used on the secondary circuit.

The Motor-generator unit, No. 8, to illustrate the convertible nature of a motor, has a small motor belted to the larger motor. The line current is fed into the field of the small motor, and its armature current is used to light a low voltage lamp.

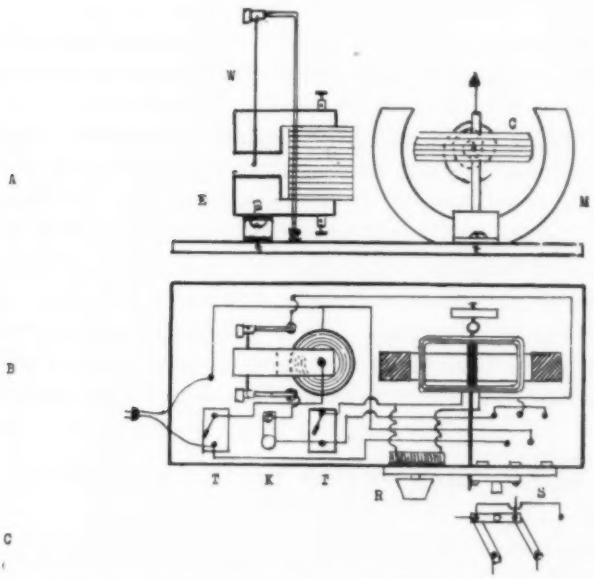
Unit No. 9 comprises two features, one showing the side push of a wire carrying a current in a magnetic field, and the other illustrating the D'Arsonval galvanometer principle.

For the first a field magnet from an old motor was used. The coil was enlarged and pieces of soft iron were added to decrease the gap between the poles. The magnet is mounted upright and



MOTOR GENERATOR UNIT No. 8

A motor belted to another small motor which is run as a generator supplying current to light a low voltage lamp.



MOTOR AND GALVANOMETER PRINCIPLES UNIT No. 9

A—Profile sketch of electro-magnet, E, with swinging wire, W; and of permanent magnet, M, and rotating coil, C.

B—Wiring scheme of the unit showing resistance control of coil, R and reversing switch, S, contact key, K, and switches, T.

C—Detail of reversing switch.

a loop of wire is suspended between the poles. The swinging part is covered with insulation to make it large enough to be easily seen.

A single pole switch turns the current on the coil. The contact key, K, controls the current in the swinging wire. The reversing switch, S, permits the current to be reversed in the wire but not in the coil.

The galvanometer feature has a large semicircular permanent magnet, six inches in diameter, made in one of our forge classes.

The coil was wound on a cardboard box through which a knitting needle had been thrust to serve as an axis. Before inserting the needle a small piece of wood was tacked across the box and the needle was forced through this. The friction of the wood makes the needle turn with the coil. After the coil was wound the box was trimmed to it.

The coil support on the operating side is a piece of bakelite panel on which the control resistance and reversing switch are mounted.

The other support is a vertical rod to which one end of the hairspring is attached. That end of the knitting needle is turned up with a cardboard arrow to serve as an indicator.

The current is controlled by a single-pole switch. The direction and strength of the current are controlled by the reversing switch and resistance, R.

Of course the parts used in such assemblies are limited to use for that one thing only, but they are not in general expensive, and often parts of discarded apparatus around a laboratory may work in to good advantage. The important consideration is that they are great time savers and afford opportunity for demonstration without using too large a portion of class periods.

BLOOD TRANSFUSION CALLED BEST TONIC BEFORE OPERATIONS

Human blood, accurately typed and carefully injected into the veins by competent surgeons, is the best possible tonic for a number of conditions, Dr. John J. Shea of Memphis told members of the American Academy of Ophthalmology and Otolaryngology.

Among the conditions for which he advised it are: before operation on weakened patients; loss of blood by accident or by slow seeping away; destruction of blood by infection, as mastoid disease; and diseases of the blood itself such as hemophilia, the hereditary bleeders' disease, and purpura hemorrhagica.

Blood transfusion is also valuable, he said, for giving a temporary supply of missing white blood cells in agranulocytic angina.

LOGARITHMS VERSUS COLOGARITHMS[1]

By Cecil B. Read

The Municipal University of Wichita, Kansas

For several years there has been widespread criticism of much of the subject matter of mathematics, one of the arguments being that for many students the subject matter is of no use in later life. Without entering into the merits of this argument, it might be pointed out that there is also need for investigation of the *efficiency* of certain methods of computation which are frequently taught.

No one would question that logarithmic computation is one of the most efficient and labor saving methods known to the mathematician. In an attempt to further simplify the labor of computation, many computers utilize cologarithms. No objective investigation seems to have been made in an effort to determine the relative efficiency of computation by the use of logarithms alone as contrasted with computation by use of logarithms supplemented by cologarithms.

In an attempt to determine present practices with respect to the teaching of cologarithms, personal conferences were held with 112 teachers. There was almost equal division into three broad categories: 32 teachers omit the subject altogether, 50 mention the subject but briefly, while 30 stress cologarithms, insisting that the pupil compute with them whenever possible. The teachers interviewed seemed to be a random sample selected from the middle western states, and represented both high school and college practice. No teacher was able to offer objective evidence supporting their practice, although many expressed the desire for such information.

Before it is possible to compare the efficiency of the two methods it is necessary to have some kind of measuring instrument. Since the type of test required should emphasize computations in which cologarithms are supposed to show an advantage, many problems which appear on available tests involving logarithmic computation are extraneous. Furthermore, duplicate forms are required.

It seemed best, therefore, to construct a test which would satisfy the peculiar requirements. After some consideration, it was decided to use a test consisting of five computations which

[1] Based upon Read, C. B. *Logarithms versus Cologarithms*. Unpublished Doctor's Field Study, Colorado State College of Education, Greeley, Colorado, 1936.

were to be carried out. Care was taken to select problems which involved the type of computations for which cologarithms are suggested, this meant that every problem would of course involve a division. Extreme care was exercised to insure that the two forms should be as nearly as possible of equal difficulty, for example, the difficulties arising in interpolation were carefully considered and adjustments made so that the two forms should have the same possibilities for errors.

To roughly determine the equivalence of the two forms, as well as the time limit, an experienced teacher, a rapid and accurate computer, worked the five problems of each set, with an interval of three days between the two trials. The time required varied by only five seconds, sixteen minutes and forty seconds being required for the second set (the shorter time). For student use, twenty minutes were allowed.

By use of the duplicate forms method, it was determined that for measuring logarithmic computation, the test had a reliability of $.862 \pm .014$; and when measuring computations involving cologarithms, a reliability of $.870 \pm .017$. For these determinations, 180 and 157 students respectively were used; in both cases the students involved were enrolled in freshman mathematics courses at the Municipal University of Wichita during the academic year 1934–1935.

Various methods of scoring yielded slightly different results, the one finally selected was that which yielded the highest reliability coefficients. This method took account of the fact that different students used slightly different methods, and hence an unequal number of steps in solving the problem. Since any method used might be correct, it was not feasible to allow a certain amount of credit for each step carried out correctly. Students who used a correct but longer method would be penalized by the additional time consumed. The scoring method adopted consisted in deducting from an arbitrary mark of 100 one point for each error made. An error was interpreted as meaning any mistake in obtaining a logarithm or cologarithm, an error in a fundamental operation, or an incorrect method. Not more than one error was charged to any single step, for example, if a logarithm appeared to have an error in both characteristic and mantissa it was counted as a single error. This seemed advisable because in some cases it was impossible to determine whether the error consisted of one or two parts. Work following an error was scored as if the step in which the error

occurred had been carried out correctly. Work omitted entirely was scored as one point deduction for each step required to complete the problem by the shortest method.

In the comparison of the two methods, fifteen sections of freshman algebra at the University of Wichita were used. These were regularly formed sections, ranging in enrollment from eleven to thirty-eight students. Some sections consisted of students who had presented only one unit of high school algebra for entrance, others consisted of students who had presented one and one half units of high school algebra. In all, 387 students were used.

The topic of logarithms was presented to all sections in the usual manner, using class lectures and discussions, textbook assignments, outside problems, and board work. Six one hour class periods were devoted to the material, after which the first form of the test was given. Following this test, the subject of cologarithms was taken up, the treatment being in the same manner as the previous work. Three one hour class periods were utilized, followed by the second form of the test. Interviews indicated that the periods used are fairly representative of common practice. The methods were presented in as impartial a manner as was possible.

The attention is centered upon a very few questions: the average score by each method, the amount of difference between these average scores, and the significance of the difference. It will be of interest to note the correlation between individual scores obtained by the two methods, in other words, does an individual with a high score by one method obtain a relatively high score by the other method?

For logarithmic computation the mean score was 82.06; when cologarithms were used the mean score was 78.93. The standard deviations were 5.31 and 5.65 respectively. The coefficient of correlation between the scores was $.87 \pm .012$. Although there is apparently an advantage in favor of computation by the use of logarithms alone, investigation shows that the difference has no statistical significance. In other words, under similar conditions, there might be no difference, or even a difference in favor of the other method.

The study made no attempt to discover the effect of a longer period of study devoted to either of the two methods. However, some light might be thrown upon the situation by the fact that in the group of 387 students there was included a subgroup of

63 students which had received high school training involving work with both logarithms and cologarithms. As might be expected, this group received an average score higher than those who had received no previous work in logarithmic computation. With such small numbers, no generalizations can be drawn, it can merely be pointed out that with this small group, the increased period of training resulted in increased average scores by both methods, but the difference between the mean scores received by the two methods remains essentially the same.

One week after completion of the work with cologarithms, 100 students volunteered to take again the identical test which they had previously worked. Logarithms, without cologarithms, were used on both trials of this test. The mean score on the second trial was .03 lower than on the first trial. The difference obviously has no statistical significance, the fact that there is no difference seems of some importance.

Advocates of the use of logarithms have claimed that definite advantages exist in the use of cologarithms. The results of this experiment fail to verify this statement, in fact, the opposite situation is indicated. However, further experimentation might show no difference. The only conclusion which should be drawn is that this experiment has failed to show the existence of a definite, unquestionable advantage in favor of the use of cologarithms. Until such evidence is presented, no such claim should be made.

The small amount of evidence available indicates that further training in either method seems to increase efficiency. Contrary to the opinion held by many teachers, training in the use of cologarithms does not result in increased efficiency in the use of logarithms. On the other hand, neither does it result in any lessened efficiency. This would seem to contradict the opinion held by another group of teachers, that the study of cologarithms confuses the student in his use of logarithms.

There seems to be no definite, unquestioned advantage in the use of cologarithms; in fact, additional time spent upon cologarithms seems to leave student efficiency at a standstill, resulting in neither gain nor loss. Apparently those teachers who absolutely insist that cologarithms must be used whenever possible are carrying things too far, possibly under a mistaken impression.

With the subject in question consisting of a somewhat minor part of a course as a whole, the available time for class treat-

ment is rather rigorously fixed. For this reason, it was felt unnecessary to investigate the question of further time for training. In fact it might well be argued that with no advantage apparent, the class periods allotted to cologarithms might well be omitted entirely. This is the point of view adopted in offering, on the basis of the present available information, the following recommendations:

1. The subject of cologarithms should not be required.
2. When there is abundance of time the use of cologarithms may be introduced as an optional method.
3. No definite statements should be made regarding the relative advantages or disadvantages of computation by either method.

Should further evidence become available, it might of course alter the recommendations.

If the suggested recommendations should be adopted, it leaves the subject of cologarithms as an optional topic. Since practices will vary in different schools, it seems quite probable that a small amount of material on cologarithms might well be included in standard textbooks. This material should definitely be marked as optional or supplementary. In addition, any statements regarding the superiority of cologarithms for certain types of work should be eliminated.

DOZEN YEARS ADDED TO AVERAGE WOMAN'S LIFE

Eleven years have been added to the average man's life and 12 years to the life of the average woman, it is revealed by life tables of the Bureau of the Census, U. S. Department of Commerce.

At the beginning of the present century, the average length of life in the United States was 48 years for white men. Now, these new figures give an average life length of 59 years. For women the average lifetime in 1900 was 51 years. Now it is nearly 63 years.

The added years of life are credited to "improved sanitation, higher standard of living, labor-saving inventions in the homes and the advances made in education and in the science and practice of medicine and surgery."

THE PRONGHORN

Wholly unique among living animals is our western pronghorn antelope, its herds now only a remnant of their once uncountable thousands. All horned animals either have bony cores inside the horns, like cows and goats, or have solid horns, like deer and moose. The solid-horned animals shed their horns once a year, the core-horned ones never shed them. But the pronghorn, alone of all horned creatures, has horns that grow over bony cores—and yet sheds them every year.

ACIDS OCCURRING NATURALLY IN FRUITS

By J. W. Neckers and T. W. Abbott
Southern Illinois State Teachers College, Carbondale, Illinois

In recent years considerable stress has been placed in the field of dietetics on alkaline and acid "ash" produced during the metabolism of various foods. "Acidosis" has been a semi-popular word to explain vague maladies but it is a term of great biochemical significance.

In general, various fruits produce an alkaline ash, that is, they leave an ash in which the basic elements predominate. Nevertheless, some acids occurring naturally in fruits may not be oxidized in the body and thus produce high acidity in the urine although the ash is alkaline. Chief among these is benzoic acid which is transformed and excreted as excessive quantities of hippuric acid. The fate of oxalic and tartaric acids does not seem to be definitely understood, some reports indicating that they are completely oxidized, others contending that they are only partially oxidized. Malic and succinic acids seem to be completely combustible. It would seem that citric acid would likewise be oxidized.

Not since 1917 has a summary been made of research for determining the organic acids present in fruits and vegetables. At that time Bigelow and Dunbar (*1*) reported the work that had been done in that field at the Bureau of Chemistry in the U. S. Department of Agriculture and also reviewed the data of other workers.

In the last eighteen years there have been a number of other contributions to knowledge in this field. Finding it necessary to collect these data to answer local queries, the authors thought it might be a service to other teachers of chemistry and related sciences to have a unit source of information on this subject. A summary of the acids occurring naturally in fruits follows:

Apples (*1, 2, 3, 4, 5*): All of the reports of the occurrence of organic acids in apples agree that malic acid is the chief acid; some say it is the only acid to be found, while others indicate small amounts of citric, succinic, lactic, and oxalic acids. Quantitative analyses by Muttelet show that the malic acid content varies from 0.13% in the juice of sweet cider apples to 0.75% in that of sour cider apples.

Apricots (*1, 4, 6, 7*): Early reports indicate the presence of

tartaric and *d*-malic acids. A later report by Nelson, however, shows the presence in dried apricots of *l*-malic and citric acids in the ratio of approximately 25 to 10, with possible traces of oxalic acid. In apricot juice Muttelet also found malic and citric acids but in the inverse ratio of 0.33% malic to 1.75% citric. Incidentally, small quantities of boric acid have also been identified in dried apricots.

BANANAS (*1*): Malic acid is the only acid that has been reported.

BLACKBERRIES (*1, 8*): This fruit is unique in that it is the only fruit which has been reported to contain isocitric acid ($HOOC–CH_2–CH(COOH)–CH(OH)–COOH$). Nelson has reported that 5/6 of the total acidity is due to this optically active acid. Moderate amounts of malic acid and traces of oxalic and succinic acids also have been reported.

BLUEBERRIES (*1, 2*): Citric acid is undoubtedly the principal acid with small amounts of malic acid also present.

CANTALOUPES (*1*): The only report found in the literature indicates that the total acidity of this fruit is probably due to citric acid.

CHERRIES (*1, 3, 4, 9*): Originally, malic acid was believed to be the sole acid present in cherries but later work shows, also, traces of oxalic, succinic, citric, lactic, and unidentified unsaturated acids. Quantitative determinations of malic acid in the juices of various kinds of cherries show a range of from 0.82% to 1.61%.

CRANBERRIES (*1, 2, 10, 11, 12*): Despite the fact that more work has been done on this fruit than on most of the others, there is excellent agreement in the various reports. The acid content is approximately 80% citric and 20% *l*-malic acids with benzoic acid ranging from 0.029% to 0.098%. Incidentally, this concentration of benzoic acid is equal to, and in some cases greater than, that used for the preservation of most perishable foods. Recent investigations have also shown the presence of quinic acid in concentrations of approximately 0.5%.

CURRANTS (*1, 3, 4, 13*): Citric acid is probably present in the largest amount with smaller quantities of malic and succinic acids and traces of oxalic and unidentified unsaturated acids. Muttelet has reported the presence of 3.5% citric acid in the juice of black currants.

DATES (*7*): Smith has reported that dates (and prunes) contain the largest quantity of boric acid of any of the dried fruits studied.

FIGS (*7, 14, 15*): Reports have been made concerning the acid content of three different kinds of figs. Adriatic figs were found to contain acetic and citric acids; Calimyrna figs, acetic and citric acids with a small amount of malic acid; and Adriatic black-neck figs, less citric acid and ten times as much free acetic acid as normal Adriatic figs. Dried figs contain 0.21% oxalic acid and measurable amounts of boric acid.

GOOSEBERRIES (*1, 3, 4*): The acid content of gooseberries is predominately citric acid with a small amount of malic acid. Quantitative determinations of citric acid in the juices of the red and the white varieties show the amounts to be quite constant: 2.08% in the red and 2.20% in the white.

GRAPEFRUITS (*16*): The only report found was to the effect that the whole fruit contains 0.67% citric, 0.0069% malic, 0.0022% oxalic, and 0.0003% tartaric acids and the juice had the same acids in approximately the same ratio but about 2.5 times as concentrated.

GRAPES (*17, 18, 19*): Concord grapes contain *l*-malic and *d*-tartaric acids in the ratio of about 3 to 2 according to Nelson. Grape juice was found to contain, besides these, some glyoxalic acid and a tartaric acid concentration of 1.07%.

LEMONS (*2*): California lemons apparently contain chiefly citric acid with a very small quantity of *l*-malic acid.

LOGANBERRIES (*2, 20*): About 96% of the total acidity is due to citric acid with *l*-malic acid contributing the remainder except for traces of tartaric acid (0.03–0.05%).

MULBERRIES (*21, 22*): Succinic acid has been isolated and is the only one reported although citric acid (15% of dry weight) has also been found in unripe black mulberries.

PEACHES (*1, 4, 7, 23, 24*): In the summary of Bigelow and Dunbar malic acid was the only acid reported. However, later reports list citric and *l*-malic acids in nearly equal proportions. Acetic acid, contributing to the odor of peaches, and measurable quantities of boric acid (in the dried fruit) have also been found.

PEARS (*1, 2, 3, 4*): In 24 varieties examined only malic acid was found in some, only citric acid in others, and both acids in a few. The Bartlett pear seems to contain about two parts of citric acid to one part of malic acid. Pear juice (variety unstated) was found to contain 0.30% malic acid.

PERSIMMONS (*1*): Malic acid is the only one to be reported present in this fruit.

PINEAPPLES (*17, 25*): The acidity is due to citric acid (87%) and *l*-malic acid (13%). Fresh pineapple has 0.499–0.808% citric acid and a pH of 3.5–4.0, while canned pineapple has 0.188–1.20% citric acid and a pH of 3.37–4.12.

PLUMS (*1, 4, 26*): Reports made prior to 1917 gave the malic acid content as varying from 0.55% to 2.15%, and appreciable quantities of benzoic acid. Later determinations give the malic acid content as 0.87%.

POMEGRANATES (*1, 2, 22*): All researches concur in the presence of only citric acid, with one yielding the information that $1\frac{1}{2}$ months before ripening the fruit contains as high as 4% acid while this is reduced to from 1.5% to 2.0% in the mature product.

PRUNES (*7, 26, 27, 28*): The principal acid in prunes is malic along with small amounts of citric, tartaric, benzoic, and boric acids. Small prunes are considerably more acidic than large prunes.

QUINCES (*1, 2, 3, 4, 18*): There is general agreement that malic acid to the amount of about 1% is the acid of quinces and of quince juice. Small amounts of tartaric (0.018%) and levulinic acids have also been detected.

RAISINS (*7*): Smith, in his report on the occurrence of boric acid in some fruits, states that a measurable quantity of that acid is present in raisins.

RASPBERRIES (*1, 3, 4, 17, 18*): Black raspberries apparently contain chiefly citric acid and a small amount (0.028%) of tartaric acid. Red raspberries seem to contain, besides citric acid, a small amount of malic acid. The juice of raspberries has been found to contain 2.12% of citric acid. No isocitric acid (the acid of blackberries) has been isolated.

STRAWBERRIES (*3, 4, 17*): The acidity of strawberries is due to citric acid (90%) and malic acid (10%). In the juice the concentration of citric acid is approximately half of that reported for raspberries, it being from 1.05% to 1.18%.

WATERMELONS (*1*): Malic acid is the only acid that has been reported; however, no recent work seems to have been done.

WHORTLEBERRIES (*29, 30, 31*): There is agreement that the acidity of the whortleberry (huckleberry) is due to 0.76–0.832% citric acid and 0.044–0.05% malic acid. However, in one variety nearly equal quantities of citric and quinic acids have been reported.

SUMMARY

In general, considering the variety and, in some cases, the small amounts of acids present in fruits, there is excellent agreement in the various reports. Many of the discrepancies are undoubtedly due to the fact that different varieties of the same fruit, as well as fruits of different degrees of ripeness, were used. Not only does the acid content change during the actual ripening process but there is also a difference in the kinds of acids occurring in the several varieties of the same fruit which mature at different times. For example, early maturing cherries, peaches, and pears were found to contain predominantly malic acid while later maturing varieties were richer in citric and tartaric acids. The natural assumption from this would be that fruits with high malic acid content would thrive in cooler climates while those rich in citric and tartaric acids would thrive in warmer climates. The analyses of 73 fruits from different climates have shown this to be the case (*32*, *33*).

In this report there has been no attempt to distinguish between the free acids and their salts as they occur in various fruits. Neither have acids which are present in extremely small amounts as, for example, salicylic acid, been included.

Acids as they occur in fruits may be briefly summarized as follows:

Malic acid: apples, apricots, bananas, blueberries, cherries, cranberries, currants, figs, gooseberries, grapefruits, grapes, lemons, loganberries, peaches, pears, persimmons, pineapples, plums, prunes, quinces, raspberries (red), strawberries, watermelons, and whortleberries.

Citric acid: apples, apricots, blueberries, cantaloupes, cherries, cranberries, currants, figs, gooseberries, grapefruits, lemons, loganberries, mulberries, peaches, pears, pineapples, pomegranates, prunes, raspberries, strawberries, whortleberries.

Oxalic acid: apples, apricots (?), blackberries, cherries, currants, figs (dried), grapefruits.

Boric acid: dates, figs (dried), peaches (dried), prunes, raisins.

Tartaric acid: apricots, grapes, grapefruits, prunes, raspberries (black).

Succinic acid: apples, blackberries, cherries, currants, mulberries.

Benzoic acid: cranberries, plums, prunes.

Lactic acid: apples, cherries.

Quinic acid: cranberries, whortleberries (?).

Acetic acid: figs, peaches.
Levulinic acid: quinces.
Isocicric acid: blackberries.

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WOMAN'S MATHEMATICS CLUB, CHICAGO

By IDA D. FOGELSON

On October 17 the first meeting and luncheon of the Women's Mathematics Club of Chicago and Vicinity was held at the Medical and Dental Arts Building with more than one hundred members attending.

The guest speaker of the afternoon was Professor Harold Fawcett of the Ohio State University who spoke on the Human Values of High School Mathematics. Mr. Fawcett showed that mathematics is the only living science and that through mathematics scientific and dependable thinking is attained. No subject in the curriculum is so great a means of molding the thinking of a child as mathematics.

The officers for this year are: President, Miss Laura E. Christman, Senn High School; Vice Pres., Miss Marie Chrisler, Kenosha High School; Secretary, Miss Lenore King, Flower High School; Treasurer, Miss Dorothy Martin, Bloom High School; Editor, Miss Ida D. Fogelson, Bowen High School; Program Committee; Miss Clara D. Murphy, Evanston High School; Miss Nettie K. Courtney, Riverside High School; Miss Neva Anderson, Evanston High School.

BASIC CONSIDERATIONS FOR NATURE STUDY AND SCIENCE INSTRUCTION IN THE ELEMENTARY SCHOOL*

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It is with considerable trepidation that I approach the task of stating a philosophy of science instruction and nature study for the elementary school. Such a task has been so frequently attempted by those more competent than I that it seems highly presumptive to assay repetition. In addition to the appearance of presumptiveness, there is also the fact that such an attempt demands a reaction to other valued contributions; a reaction which of necessity must be critical. To be critical of the efforts of others is to appear unappreciative and ungrateful. It is therefore to be hoped that we may deal with this problem in the spirit of finding *what* is right, rather than *who* is right. It is in the interest of finding what is best for the children placed under our care and guidance that I become a party to re-opening the question of the basic theory upon which is to be based an effectual practice of teaching science in the elementary school.

A perusal of current discussions of this problem discloses the fact that a matter of first importance appears just now to be that of the significance and relative placement of factual information on the one hand, and scientific generalizations or principles on the other. Ever since the appearance of Professor Morrison's stimulating volume, entitled *The Practice of Teaching in the Secondary School,* science teachers have progressively become less enthusiastic over the idea of "projectizing" their courses, and have turned to the business of "unitizing" them. At first the influence was felt only at the secondary level, but since the publication of the *Thirty-first Yearbook of the National Society for the Study of Education, Part I*, entitled "A Program for Teaching Science," with its emphasis on a science program from kindergarten to college, teachers interested in elementary school science have *also* taken seriously to the task of recasting their various subject matters into units designed to lead pupils to the understanding of principles. In this shift of emphasis I can see large value, but it also appears to involve

* This paper was read before the December, 1935, meeting of the American Nature Association at St. Louis, Mo

difficulties which do not seem yet to be fully appreciated.

Back of the project idea is the conviction that too much attention was previously given to subject matter, and not enough to the psychological needs of the child. The project idea in education appears to be a fruition of the more-than-a-century-old influence of Rousseau, reaching us through the writings of Pestalozzi, Froebel, Herbart, Dewey, and Kilpatrick. This does not mean that the project, as actually conducted in schools, accords completely with the wishes of all or, in fact, of any of these writers. It means only that the project represents *one form* which this line of thought has assumed in actual practice. That the project did not do everything expected of it is evident from the fact that the term is now somewhat in disrepute. We now hear more of units than of projects.

Finally defined as "whole-hearted, purposeful activity, proceeding in a social environment," the project at length became so broadly conceived as to cover almost any and every type of classroom experiment. Yet through it all, persisted the idea of amelioration—giving the pupil a chance to do what he wanted to do. Pupil purposing has been, and continues to be, the keynote of the project idea.

But pupil purposing is what finally strangled the project—the name I mean, rather than the idea—because the notion of letting the child do what he wanted to do, and making no consciously planned effort to shape his wants in an educative direction, began to give promise of "stealing the show." The boy, seeking to finish a piece of woodwork with a rasp instead of a plane, was not to be corrected or led to discover the advantages of the latter tool over the former, for fear of warping the development of a budding personality.

Most teachers, however, partly due to good common sense and partly to conservative training, could not stomach such practice. An overswing of the pendulum in one direction is bound to be followed by an almost equal overswing in the opposite direction. All that can stop it is the application of some damping device, usually the invention of a human brain. Said damping device being absent, the appearance of a comprehensive and attractively dressed plan for returning to the so-called "tried and true" practice of organization in terms of subject matter was greeted with open arms. The prodigal son had returned! Thus we embarked upon the business of *unitizing* our courses, and of keeping students at the units until they had

given unmistakable evidence of having "caught the central idea."

The unit idea has proven especially attractive to science teachers. While by teachers in general the term unit is now used as loosely as the term project ever was, for teachers of science the usage seems to be quite thoroughly Morrisonian; that is, an area of subject matter which is to be so taught as to result in the understanding of a scientific principle.

I have implied that the Morrison unit is an overswing in the direction opposite to the project. This feature represents at once the weakness and also the possible strength of the unit. In Morrison's own hands, and in the hands of those who follow him closely, it constitutes a major weakness. It substitutes a clearly autocratic and dictatorial type of teaching for a type which has democratic possibilities. It establishes a type of teaching in which the pupil's purpose is purely to learn what he is expected to learn, in place of a type in which the learning is less of an end in itself and is more of a mediatory achievement—a means of forwarding progress toward some other end or goal having more meaning or more intrinsic value for the pupil.

In the thirteenth chapter of his book, *Democracy and Education*, entitled "The Nature of Method," Dewey discusses certain "evils in education that flow from the isolation of method from subject matter." The third of these evils is that "the act of learning is made a direct and conscious end in itself." Let me quote Dewey's entire discussion of this point:

> "Under normal conditions, learning is a product and reward of occupation with subject matter. Children do not set out, consciously, to learn walking or talking. One sets out to give his impulses for communication and for fuller intercourse with others a show. He learns in consequence of his direct activities. The better methods of teaching a child, say, to read, follow the same road. They do not fix his attention upon the fact that he has to learn something and so make his attitude self-conscious and constrained. They engage his activities, and in the process of engagement he learns: the same is true of the more successful methods in dealing with number or whatever. But when the subject matter is not used in carrying forward impulses and habits to significant results, it is just something to be learned. The pupil's attitude to it is just that of having to learn it. Conditions more unfavorable to an alert and concentrated response would be hard to devise. Frontal attacks are even more wasteful in learning than in war. This does not mean, however, that students are to be seduced unaware into preoccupation with lessons. It means that they shall be occupied with them for real reasons or ends, and not just as something to be learned. This is accomplished whenever the pupil perceives the place occupied by the subject matter in the fulfilling of some experience." (P. 198–9)

The elementary school pupil will not often be highly enthusi-

astic over the prospect of learning a scientific generalization or principle purely as an end in itself—merely for the sake of learning the principle. He simply does not "register." Such a pursuit has no immediate meaning for him. He may, from time to time, ask a question, the answer to which involves the universe, but he will not be likely to find much satisfaction in an involved answer. For him, the question is a simple, not a universal; and he is seeking a simple answer. Whatever answer he receives he will interpret only in terms of his own experience; not in universal terms. A given answer, far from being the same for all pupils, differs from pupil to pupil in terms of individual experience. Witness the oft-retold case of the grimy, tattered youngster from the wrong side of town, caught by the principal "beating up" the banker's son. "Yes, but Mr. Jones, he called me a rhinoceros." "When did he call you a rhinoceros?" "Last year." "But why beat him up now for calling you a rhinoceros last year?" "Why, I never saw a rhinoceros till last week, and this is the first time I've been able to catch him since." The meanings of words, phrases, and sentences become altered with the further acquisitions of experience.

Let us pause for a moment to consider just what is the nature of a principle, and how a principle differs from a fact. A fact is often thought of as an observation, and a principle as an interpretation—the former objective and the latter subjective. This is probably the belief which lies back of the wide-spread conviction among science teachers that one of the most important "elements" of the scientific method is the ability to distinguish between fact and theory. I personally am inclined to the belief that we make more of this factor than is justifiable, for I cannot become convinced that a fact is any less of an interpretation than is a principle.

As I find it, a fact is an interpretation which one makes of a relatively limited set or area of data, while a principle is an interpretation of a relatively wide area, or large number, of data. We observe one incident, and are convinced that our eyes have not deceived us. We thereafter refer to the *fact* that such and such a thing happened at such and such a time. With the accumulation of similar incidents, we may sooner or later conclude that under given conditions a given consequence or chain of consequences is bound to occur. And such a conclusion we call a principle. What is a principle, therefore, other than a conclusion, interpretation, or rule which experience has shown is depend-

able and applicable in a large number of cases? Such a conclusion as to the meaning of the term principle binds us to the further conclusion that a principle is a function of the previous experience of a given individual, and therefore cannot be the same for any two individuals; nor, in fact, is it the same for any given individual at two different times. As individuals vary, principles vary. Losing sight of this fact is fatal to clear thinking regarding educational procedures. It is precisely at this point that Morrison and his followers appear to jump the track and go afield.

For example, a recent writer in *Science Education* makes the following statement: "It is assumed that the principles of science are the same at any school level." Then this writer proceeds to the so-called "scientific" derivation of one hundred thirteen science principles which he appears to believe one can accept as unquestionably suitable for teaching to elementary school pupils. Such is the hazardous complacency of many of the self-styled "scientific" educators. Theirs not to reason why; theirs but to cut and try!

There is much which might be said about the article, but my time is limited. However, one feature may be noted as an example. The writer asked about fifteen experts in elementary science to evaluate a given list of science principles as to suitability for inclusion in the elementary curriculum. He suggested no criterion whatsoever as to judging suitability, leaving each expert to use his own criteria. It is small wonder that he must conclude that "there is a wide range of opinion among these elementary science experts with respect to the suitability of the various principles." How could it be otherwise? How can we come to agreement as to what subject matter is suitable in a given field before we agree as to what we wish to accomplish in that field? How can you tell me the correct road before you know where I want to go? In spite of this obvious fault, the writer unfalteringly concludes that his plan "secures . . . 113 defensibly stated principles and subsidiary-principles appropriate to serve as ultimate goals of science teaching in the elementary school."

But the major fault of this particular study (and of the entire teaching philosophy which it represents), as I find it, is the not-always-stated assumption that "the principles of science are the same at any school level." If there is any truth to the previously stated proposition that a principle is *not* the same for

any two individuals, then it must surely follow that any given principle cannot be the same for two different school levels, even though it be stated in identical terms. This is exactly the problem that Freeman raised in his criticism of the report of the 31st Yearbook committee. Moreover, if this be true, it would also further follow that the effort to describe and define the elementary science curriculum purely in terms of principles-to-be-learned is a futile, senseless, and thankless task.

I have now given—although inadequately—two reasons why the emphasis upon principles by Morrison and his followers is an overswing—possibly in the right direction, but surely too far. The first is that the elementary school child has not yet reached the level of intellectual maturity to become capable of sustained interest in the learning of a scientific principle for its own sake. The second, closely enough related to the first to become almost a corollary, is that the definition of the term principle which underlies such a view is logically and psychologically unsound. For these reasons I therefore object to such a view in elementary science.

There is a third objection to this overemphasis; namely, that the swing is to the side of a domineering, dogmatic, autocratic attitude on the part of the teacher. This, in turn, tends to promote a docile and unthinking attitude on the part of the pupil; an attitude of unquestioning acceptance of authority. Neither attitude is in keeping with the democratic ideal nor with the spirit of science.

When a teacher becomes convinced that a given scientific study has placed him in possession of one hundred thirteen principles (or any other number, for that matter) which are *the* outcomes that *must* be achieved in a given period of instruction, the "mastery formula" technique—teach, test, diagnose difficulties, adjust procedure, teach, and test again, to the point of actual learning—or some variation of such a technique, is almost bound to be adopted. Traditional teaching—the re-citation procedure—was never more autocratic or domineering than this; even if one grants the Morrisonian distinction between the re-citation of facts and the "mastery recitation" of principles. I do not believe that we can possibly justify the selection of *any* set of scientific principles, regardless of scientific exactitude, if these principles are to be taken out of context and considered as the "ultimate" ends of elementary science instruction. The essentials of a thorough elementary education are not to be de-

fined in terms of any group of set, specified achievements. An education is not a matter of particular achievements; it always eludes any such; it is never safe to claim that an individual who does not possess certain items of information or ability is not educated. We may be justified in saying that he will be handicapped without them; more than that is a dubious claim.

It is a mistaken notion of the needs of a democratic society that all people must possess the same knowledge and the same abilities. In fact, in one sense the exact opposite is demanded. Diversity, rather than uniformity, is the need. Each individual must make his own unique contribution to the common good if a complex society is to be successful. Moreover, we have the word again and again from representatives of industry that they can better use young people whose preparation is broad and generalized, rather than narrow and too highly specialized. It is *ability to learn* that is wanted, rather than the possession of particular learnings.

If all this be true, what can be the justification for making a more or less arbitrary decision that such and such a principle must be learned, and then keeping the child at it until he learns it? Clearly, there must be some disciplinary value in learning a given something and learning it well. I believe that one does not have to be a formal disciplinarian in order to hold that a child receives benefit from discovering progressively the advantages of precise and thorough knowledge. It is doubtless advantageous to possess as much accurate and dependable information as possible. The hitch appears to come when the school attempts to say, arbitrarily so far as the student is concerned, exactly what that information must be. It is probably reasonable to hold that this question is one which must be settled by each individual for himself. During formal schooling, many items have to be neglected. If later experience shows certain of these to be needed, the one who has *learned how to learn* will usually be able to dig those out for himself; the one who has never learned how to learn by himself will be lost.

Out of this apparent conflict there seems to emerge a real need for learning some things well. But it may also be that other things need not be learned quite so well, while still others may merely be introduced and left as vague impressions, or as unsolved problems consciously side-tracked for others which are at the time more pressing. The old adage that "what is worth doing at all is worth doing well" must not be taken too seriously.

Some things have to be "given a lick and a promise"; else there will not be sufficient opportunity for doing the important things well. Is it not conceivable that even with a large class a given subject matter area may be broken up and treated in a diversified manner so that each pupil, while following the general trend of the class as a whole, can develop as his own special contribution some particular phase, and then give the class the benefit of his individual researches upon the proper occasion? Is this not a more democratic procedure?

The need which such considerations imply is that every pupil must be taught to learn by himself; at least in so far as his capacities will permit in the allotted time. Probably the most significant task of the teacher is to make himself progressively unnecessary; to teach the pupil in such a way as finally to make the pupil capable of teaching himself.

Such an outcome is not to be achieved by forcing the pupil to learn a fore-ordained list of 113 scientific principles. He may learn all of them, and more, or he may learn only part of them. The important thing is that all instruction be handled in such a way as to stimulate the pupil's reflective abilities; challenge him to gather data, compare hypotheses, weigh evidence; to adopt only conclusions which the evidence will support, and hold them only so long as the evidence continues to support them. It is thus evident that the teacher must not tell the pupil what conclusions the pupil must adopt. Always must the way be open for the pupil to disagree with the teacher if such is his thoughtful conviction. This means problem teaching; but not the kind in which the acceptable or so-called right answer is presented as soon as the problem is broached. The child is entitled to know the teacher's convictions, but probably not before his own and those of his fellows have been given a thorough airing. Even then, the teacher's answer should be thrown into the ring along with the rest; and may the best answer win! Thus, I would hope for a democratic, cooperative attitude on the part of teacher and pupil alike, rather than one which is domineering and unbending, either on the part of the teacher or of the pupil. Autocratic pedagogy is likely to produce a domineering teacher; soft pedagogy a domineering pupil.

Now, when we say that any given topic must be treated in such a way as to enhance the scientific or reflective abilities of the pupils, we still leave much unsaid. How shall we select the topics to be so treated, and what direction should the dis-

cussions assume? By saying that the topics to be selected must be *problems*, we adopt a criterion that is quite selective; more so even than is at first evident. This means that each topic must come to the pupil in such a form as to constitute for him an arresting situation; a situation for which he has no immediate answer; a situation which is for him a real question mark; a forked-road or no-road situation.

This criterion means that something must be done with the subject matter of science which some may consider makes it other than science. The subject matter of science does not become such until it receives sufficient corroboration to render it relatively established or settled. No principle or law is called scientific until scientists become very sure of it. Thus, if one proposes to teach scientific principles as such, one virtually eliminates problem teaching. That is what science teachers almost universally are doing. That is why their so-called problems are not really problems at all, but are merely questions which are answered almost as soon as they are asked. The common practice of labeling them problems does not alter this fact.

The only way to effect real problem teaching is to *unsettle the settled nature of the subject matter;* at least, for the class, and at the outset of the discussion. Doubt must be thrown upon a previously settled conviction. This cannot be done by introducing the universal (the generalization or principle) at the beginning. This can only be done by starting the discussion through the introduction of particularized cases, as familiar to the class as possible or practicable, and so handling them as to introduce a difficulty which the class will appreciate as a real one.

For example, one may wish to introduce a second or third grade class to some of the lore of the weather prophet; say, the principle of moisture precipitation. With this in mind, the teacher might "happen" to notice that the children's shoes are wet, even though it has not rained and the pavements are dry. Adroit questioning discloses the fact that the grass is wet, and it also comes to light that the children who have wet shoes are only those who walked across the grass. Now what caused the grass to be wet when there was no rain and the pavements are dry? This question may or may not immediately establish a problem. The class is quite likely to be satisfied with the statement that there is dew on the grass. But why isn't there dew on the pavement, and why is there dew on the grass? Does dew

"fall" on the grass? If so, why doesn't it also fall on the pavement, as does rain? By this time the class as a whole will probably be "pretty well stumped." They will be face to face with a "no road" situation. A previous concept—that of falling dew —was suddenly found to be inadequate because it appeared to conflict with some recognizably pertinent evidence.

How harmonize this conflict? Well, possibly the grass is "sweating." But people sweat when they get warm. Has the grass become warm? Hardly, because dew is present in the morning only when things are cool, and disappears when they become warmed by the sunlight. What things "sweat" when they are cooled? Oh yes, a pitcher of ice water on a warm day, or a window on a cool morning. Where does the "sweat" come from? If the grass is cooled, why isn't the pavement also? Does air always deposit moisture when it is cooled? Does it have to be cooled always to a certain temperature? Why is the moisture-depositing temperature sometimes low and sometimes high? Why does a wooden vessel not "sweat" while a metal vessel does? Why do thin things, like grass and leaves, gather dew while thick things do not? And so, ad infinitum.

One has to stop somewhere because of the demands of other subject matters. Suppose one stops here. Does the class understand the principle of precipitation? Could all, or any, of the class members stop here and answer adequately the question of what clouds are and why they form? I doubt it. Yet what I have outlined is enough to occupy several nature study periods, and probably represents as much time as the teacher would feel justified in allotting to it. And the principle of conductivity of heat has also been introduced; if not others. Clearly, much is left for another time, be that a month, a year, or several years later. In the meantime, the question will ramify to different levels and in different directions in the minds of the various class members. Just where is *the* principle?

This is exactly the problem which causes me to hesitate at defining a curriculum in terms of principles-to-be-taught. The instruction has caused the pupils' thinking to move *in the direction of* generalization or interpretation, but has not been regimented into arriving at any pre-arranged *particular* generalization. The particular generalizations are not the "ultimately" important factor; more important is the pupils' growth in the realization of how generalizations—scientific generalizations or principles, if you will—are reached. He has had brought home

to him in one specific set of instances the scientific way of thinking. An accumulation of such experiences will some day serve as the basis for bringing him to a conscious formulation of the essentials of the process known as the method of science, and will have aided in clothing it for him with an emotional coloring which will lead progressively toward greater allegiance to it as a method of his own. Thus we make progress from week to week and from year to year in producing scientifically minded students and citizens.

Therefore, in summary, I would say that my philosophy for teaching science in the elementary school is somewhat as follows: First, handle the classroom at all times in such a manner as to enhance the reflective abilities of the pupils, and by this means teach them as many facts and principles of science as one can possibly chuck into their respective minds in the allotted time. Second, for introducing subject matter, select incidents, either familiar or unfamiliar, which one has found to be fruitful in precipitating challenging and arresting problems; problems which are such by virtue of the intellectual conflicts which they involve; problems which give promise of solution or resolution at the level of maturity which the class represents. Third, in order to solve the problems, seek always to guide the thinking of the class toward the formulation or discovery of principles or interpretations which will bring the factors of conflict into harmony one with another. This is the teacher's basis for criticism. Fourth, before leaving the problem, be sure to provide leads into other problems which in turn are progressively more complicated and must be reserved for later treatments. Above all, do not let the child leave with the feeling that he has settled, once and for all, the affairs of the world. Such an attitude is fatal to further growth. It is not the attitude of a scientifically minded man.

Thus, we have a teaching technique which consistently and persistently takes its start in the discovery and isolation of conflicting phases in the pupil's outlook on life, and moves always in the direction, through the harmonization of these conflicts, of a more complete and more far-reaching unification of this outlook; the type of outlook which is characteristic of the intellectually mature, cultured adult who represents the ideal product of an effective and efficient educational program. Such a technique, in a very real sense, harmonizes the apparent conflict between the project idea and the idea embodied in the

unit. It does so because it demands that the teacher recognize always the psychological needs of the child—the need of dealing always with interesting materials—and yet furnishes a basis for guiding and shaping his interests always in an educative direction; doing so without recourse, except in isolated cases, to the outright coercive discipline of a schoolroom practice which should now exist only as one of the grim spectres of history.

MENDELEEFF (1834–1907)

By SR. M. AGNESE, N.D.
St. Joseph's High School, Fremont, Ohio

"Refrain from illusions, insist on work and not on words. Patiently search divine and scientific truth."(1) These words from a dying mother to her favorite son of sixteen years, served as a beacon light during Dmitri Mendeleeff's years of scientific search, culminating in his great discovery of the Periodic Law, which overwhelmed the whole scientific world in 1869. Maria, his mother, had been burdened with the support of the family upon the early death, from consumption, of Iwan Mendeleeff, Dmitri's father.

In appearance a genuine Slav, of medium height, powerfully built, with expressive deep-set blue eyes, high cheek bones and an immense forehead, bushy with hair, Mendeleeff always attracted attention wherever he went. Though extremely sensitive and temperamental, at heart he was kind and lovable, as is evidenced by the remark, that "of all things I love nothing more in life than to have my children around me."(2) Six children were the fruit of his two marriages. His second wife, an artist of Cossack origin, seems to have appreciated Dmitri's rare gifts. By wifely devotion, she brought out his dormant finer qualities. This accounts for his breaking away from the conventional Russian attitude toward women, whom he employed in his office and admitted to his classes—a great innovation in that day.

Dmitri Mendeleeff was born in 1834 at Tololsk, Siberia, the youngest of seventeen. When seven years old, he began his formal schooling; his exceptional memory was manifested by his brilliant success in mathematics, physics and history. However, he evinced an unusual repugnance for the classics.

Surgeons gave Dmitri, when sixteen years old, but six months to live. The six months developed into more than three score and ten years. Music was his favorite form of recreation, though he was rarely seen in a theatre. True to his nationality, he understood the tyranny and brutality of a beaurocratic Russia, though he was neither a revolutionist nor a republican. This scientific genius, a royalist at heart, frequently evinced signs of political eruption, which necessitated his being hastily sent away on some government mission. One day in February of 1907, pneumonia claimed the enunciator of the Periodic Law.

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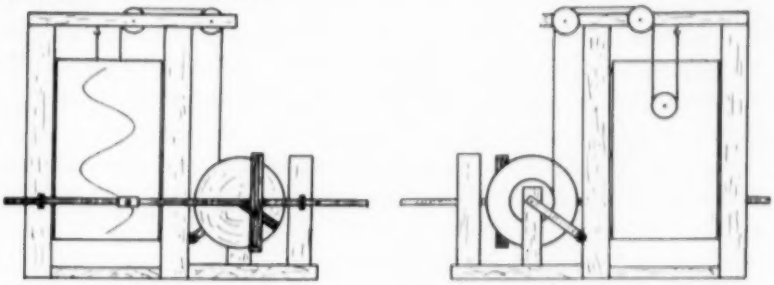
MECHANICAL DEVICES FOR DRAWING LISSAJOU'S FIGURES

By R. C. Colwell
Professor of Physics, West Virginia University

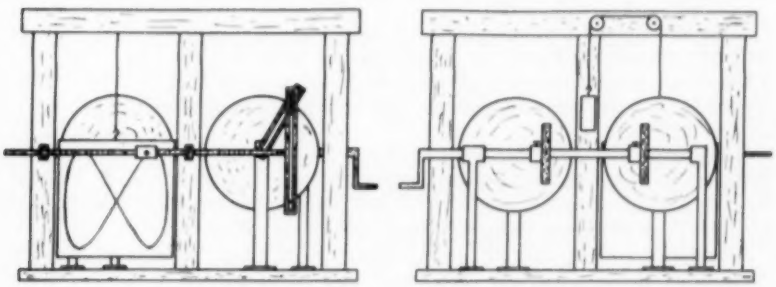
This device which produces all the Lissajou's figures upon a small blackboard is based upon a simple machine invented by Mr. Fullmer of our laboratory. The machine described below will draw sine, cosine and straight line curves with simple combinations of the three.



Front view Rear view

Fig. 1. Mechanical devices for drawing Lissajou's figures.

A wheel with a slot in it (Fig. 1) has a rod sliding back and forth in simple harmonic motion as the wheel rotates. One end of the rod may be set in the slot so as to give different amplitudes, and a piece of chalk is attached to the other end and pressed against the blackboard by a spring. The blackboard is



Front view Rear view

Fig. 2. Mechanical devices for drawing Lissajou's figures.

fastened to the axle of the wheel by a string which winds and unwinds from the axle. Thus the piece of chalk moves horizontally in simple harmonic motion, while the blackboard moves vertically up or down with uniform speed. Hence the chalk marks

out a sine or cosine curve according to the setting of the rod. It is also possible to add or subtract these simple functions mechanically. The straight line motion of the blackboard gives the proper axis.

If now the blackboard is attached to a slot in a second wheel (Fig. 2) it can be made to move in simple harmonic motion. The combination of its motion with that of the chalk, gives two such motions at right angles—the proper combination to produce Lissajou's figures. If the two wheels are geared directly there is a one to one ratio. With suitable gears it is possible to get 2:1, 3:1 and so forth. In our machine, the velocity ratio of the two wheels is governed by placing two rubber friction wheels at different distances from the axles of the wooden wheels. This is sufficient for demonstration purposes; but for accurate drawings, it would be preferable to have metal cog wheels.

The moving blackboard is about one foot square, so that the figures are visible to a large class.

EVOLUTION

By E. E. Watson
Iowa State Teachers College, Cedar Falls, Iowa

Softly the moonbeams are playing, as lightly they steal o'er the plain;
Where waves once tossed in their glory, like the swells on a rolling main.
Forests now add to the beauty, and flowers and birds come and go;
Bringing the seasonal changes, with garlands of green or of snow.

Gently the aurora is mounting, her fingers are streaking the sky;
Nature primeval is flaunting, it's an age but never a why.
Then on the breeze comes a whisper, in the vales are the shadows of men—
Nature's own method of building, repeated again and again.

The dance of the faries has ended, how like a prelude to a game;
Where once were the forces of nature, now reason lifts high its fair name.
Learning has brought in new visions, and science has pushed back the sky;
Standards of life have ascended, the Cross is the story of why.

Above the chaos of nature, law, order, and harmony sit;
Where once rode death and destruction, like tyrants on a galley ship,
Forces of nature now serve us, with marvels of truth and of love,
Ours is a world in the making, unfolding of plans from above.

Out in the gardens of heaven, where cunningly nature has wrought,
The lovely stars are explaining creation is only a thought.
Nature unfolds its own message, a one-ness in purpose and plan;
A message of law and of order, in the evolution of man.

HORNER'S METHOD—SHORTENED

By Hollis D. Hatch
English High School, Boston

When the real root of an equation above the second degree is wanted acurately, Horner's method is the old standby. The worst objection to the method is the numerical work which increases with each figure. The following shows how to get an answer to two, and often three, more decimal places for a given number of depressions.

After the original equation is depressed to a new equation, one of whose roots lies between zero and one, it is of the type ending in $\cdots bx^2+cx+k=0$ (Eq. 1). Many algebra texts point out that since x is less than unity, the square, cube and higher terms are small so that a rough value for the root can be obtained from saying: $cx+k=0$ or $x=-k/c$ (Eq. 2). This is sometimes useful but since it is a linear approximation it may be a poor fit to a curve with a distinct curvature. A curvilinear approximation would be obviously better and can be gotten as follows:

Consider the result of dividing c^2x by $(c-bx)$. The quotient $cx+bx^2+\frac{b^2x^3}{c}+\cdots$ is a series which is convergent for x between $+1$ and -1. For such values the cube and higher powers are small and $\frac{c^2x}{c-bx}$ is a good approximation for bx^2+cx. Let us substitute then for the last two x terms of Eq. 1:

$$\frac{c^2x}{c-bx}+k=0$$

then $c^2x+kc-kbx=0$

$$x(c^2-kb)=-kc \text{ and } x=\frac{kc}{kb-c^2}.$$

This is less easy to calculate with than if we continue:

$$\frac{1}{x}=\frac{kb-c^2}{kc} \text{ and finally: } \frac{1}{x}=\frac{b}{c}-\frac{c}{k} \text{ (Eq. 3).}$$

This, it should be noted, is only an approximation because the cube and higher terms have been omitted but it becomes increasingly accurate as the omitted cube terms become small. This is when x becomes small.

Let us take a problem: The equation $x^3-2x^2+3x-5=0$ (A) has a root 1.843734+. When Eq. A is depressed in the usual way we have $x^3+x^2+2x-3=0$ whose x is between 0 and +1 The use of Eq. 2. gives $x=1.5$ which is obviously useless. Let us use Eq. 3:

$$b=1 \quad c=2 \quad k=-3 \quad \frac{1}{x}=\frac{1}{2}+\frac{2}{3}=\frac{7}{6}$$

$$x=\frac{6}{7}=.86-.$$

This—since we know the answer—we can see is much better and shows we should use .8 to get the next depressed equation, $x^3+3.4x^2+5.52x-.248=0$ (Eq. C), whose x is between .01 and .1. Using Eq. 2 gives $x=.04493$; and Eq. 3 gives $x=.04372$ which is obviously better. Using .04, the next depressed equation is: $x^3+3.52x^2+5.7968x-.021696=0$ (Eq. D) whose x is between .001 and .01. Using Eq. 2 here gives $x=.003743$ while Eq. 3 gives .003735. Just to be sure we will take the next depressed equation: $x^3+3.529x^2+5.817948x-.004273893=0$ (Eq. E). Here Eq. 2 gives .0007345 while Eq. 3 gives $x=.0007344$. Thus we have the root to four places by Horner's method but we might just as well have stopped at Eq. C and used our new Equation 3 and saved ourselves considerable arithmetic.

We now see that x from $1/x=b/c-c/k$ is always better than $x=-k/c$ and secondly, it is an exact way of calculating two figures beyond where you stop in Horner's method with an excellent estimate of the third figure.

In practice you decide that you wish a root to, say, six decimal places. Then you get the whole number part in the usual way, apply Eq. 3 roughly (mentally or with a slide rule) to the depressed equation each time to get the next figure until you have at least three decimal places. Then using the coefficients b, c, and k of the last equation, you get b/c with a slide rule and c/k using logarithms. Thus the last two or three and most tiresome steps of Horner's method are avoided without loss of accuracy.

SECOND HAND BRICK INFERIOR

Walls of second-hand brick will stand only half as well—and half as safely—as those built of new and unused brick. This has been shown by tests upon 10,000 bricks by the University of New Hampshire's Engineering Experimental Station.

Mortar clings only half as well to second-hand brick. Bricks have pores and in these pores the mortar penetrates to make a perfect bond or joint between bricks. Brick once used has had part of these pores filled.

LIFE DORMANT

By Karl Huxley Sjovall
Teachers College of Connecticut, New Britain, Connecticut

[Note: Mr. Sjovall, senior at the Teachers College of Connecticut, carried on this investigation in connection with laboratory work in a course in the teaching of junior high school science. It represents a type of approach which may be made, starting with the environment, and having as outcomes familiarity with certain types of organisms and ability to use classification keys in determining species. Such activity gives training in observation, in using reference material to gain desired information, and in expressing the results of such study in an informal way. It is thought that this form of report may be more useful in some ways in meeting the objectives of education on the junior high school level, than the usual more formal type of scientific report.—O. E. Underhill, Instructor in Science, Teachers College of Connecticut.]

Making my way through snow that was six inches or more in depth, with two large cans and a large spoon in my hands, I was on my way to collect no more interesting a thing than mud. Mud to me was just a mass of silt, gravel, and slime. That I should be gathering this mud to find any forms of life that it might contain, seemed rather foolish, especially in the winter. The quiet spots in the brook were frozen over and I had to break the ice in some places before I could get at the mud at the bottom of the stream. I was little interested in this expedition out into the snow. My wet hands seemed cold enough to freeze and the snow was making a strong bid to occupy the inside of my shoes. However, as soon as I was back in the warmth of the laboratory and had started to analyse the mud, this work began to fascinate me. With each new evidence of life that I found, I was urged on to look for more. It was a revelation to me that a thing such as mud, which at a glance looks to be so devoid of life, can be so alive, and with so many kinds of life. Upon finding life present in the mud, it was only a natural thing that I should want to find out just what kind of life I had found.

The classification of the life found was quite laborious, and yet interesting. I feel that I now have an increased appreciation of the minute forms of life, a knowledge of many kinds of aquatic forms of life, and an ability to classify organisms as I find them.

In the following paragraphs I shall attempt to describe just what I did, what I found and how I classified what I found. To work with a microscope is very fascinating. It is like taking an

expedition into some strange land. Things that look so simple in ordinary examination, take on a complexity and intricacy of which one without the use of a microscope would never dream.

After scooping some mud into cans, I took it to the laboratory. I had been careful to scoop off the surface of the stream bed down to a depth of about two inches. I carefully examined this choice mud, using forceps, a small spoon-shaped stick and a match stick. When I saw any twig or dead leaf, I placed it in a small bowl in which I had placed some water. Upon washing these twigs, I sometimes came across what I first thought were small worms. Upon a close inspection of them under a hand lens, I began to question as to just what they were. I had been advised concerning a good book dealing with this type of work, namely, *Field Book of Ponds and Streams* by Ann Haven Morgan. In this book, I found a picture of my "worm."

What I had thought to be worms were in reality midge larvae.[1]

As I continued to examine the mud, I came across some organisms even more closely resembling worms. Every time I counted the segments I got a different number, but I think I am safe in saying that it had at least thirty. Again consulting Morgan's *Field Book*, I decided that I had found some bristle worms. "The fresh water bristle worms or Oligochaetes are either bristle-bearing worms about half an inch long, or small aquatic earth worms easily recognized as such."[2] It is the latter form that I observed. These worms are built like earthworms and behave like them, overturning the ooze of pond bottoms as thoroughly as earthworms overturn the topsoil of the land. Their slender, cylindrical bodies are divided into segments set off on the inside by muscular partitions, and on the outside by clearly defined constrictions. They have no fleshy outgrowths along the sides of the body. These bristle worms feed on decayed organic matter, especially plants; they are constantly cleaning up the pools and they are largely responsible for the quick disappearance of dying algal mats in the fall.

I placed some of the mud in jars, filling the jars three quarters full of mud with a little water over the surface. In other jars I placed a small amount of mud in the bottom and then filled them with water. I let these jars stand for about a week.

When the mud had settled, I observed in the jars containing

[1] Morgan, Ann Haven. *Field Book of Ponds and Streams*. Putnam's Sons 1930, pp. 139–140.
[2] Morgan, op. cit., pp. 140, 143–144.

only a little water something that was very interesting. Sticking out of the surface of the mud were slender brownish worms about three quarters of an inch long and swaying back and forth with a vigorous motion. When I went to touch them with a match stick, they quickly withdrew into the mud in which they had built tubes. When I looked up this worm, I found it to be called a tubifex.[3] These are tube building worms with their heads in the mud, and tails pointed upward above the surface of the mud. Their tails seem to be in constant motion. The tubifex feeds on the decayed matter in the mud. As they feed, the waste from their bodies is cast out from the ends projecting above the mud and thus they make a constant overturn of the mud very much like the earthworm does on land.

These tubifex were the last signs of life that I observed in these jars. I have kept these for a long time, but there seems to be no further developments. This is not the case with the tall jars that I previously referred to. After about three weeks, I noticed that there was a green scum forming on the bottom. I let this grow in the sunlight for a number of weeks and watched it. One day I noticed a small white speck moving about in the water. My mind was immediately taken away from the algae or green scum, and focused upon this small, almost invisible white speck. Sometimes it would disappear right before my eyes, and then suddenly show up again. How could I catch it and be able to get it under a microscope? A net would be of no avail, as I wouldn't be able to see it against the background of a net. I finally hit upon the idea of lowering a small beaker into the water and raising it when I had any kind of reason to suspect that the speck might be in it. After a number of trials I was successful. I had now captured this speck and had it safely inside a small beaker. In the small beaker I found that it was much easier to follow its movements. It was undoubtedly some kind of a small aquatic animal and moved about quite rapidly with a jerky motion. The problem that now confronted me was how to get this animal on a slide so that I could look at it under the microscope. I solved the problem by using an eyedropper. Pressing the bulb of the eyedropper and thereby forcing out the air, I followed the little creature around the small beaker with the open end of the eyedropper. When I caught up with it, I released the bulb, thus drawing in the water in the vicinity surrounding the animal. If I was lucky I would have

[3] Morgan, op. cit., pp. 145–147

sucked him up into the tube. I soon became a very efficient fisherman, using an eyedropper instead of a line and hook. Once having captured the animal, I dropped water on a clean microscope slide, drop by drop, examining each drop. If the drop did not contain the animal I was after, I wiped it off with a clean cloth. When I finally had it isolated in a drop of water on the plate, I placed the plate under the microscope.

The animal, that I found under the microscope, seemed very peculiar to me. It seemed to lack any semblance of symmetry. I had called others who were in the laboratory to look also. After all the others had examined it, I took another look and to my amazement saw two perfectly symmetrical little creatures. At first I almost questioned my own sight. I was later to find out that I caught these two creatures in an unguarded moment . . . they were mating. This animal had a pear-shaped body tapering into a forked tail, a pair of long antennae, outspreading like antlers, a single eye in the middle of its head, and four pairs of swimming-feet on the thorax. The animal is very transparent and its stomach cavity was quite visible.

The book that I used to identify this animal, *Fresh Water Biology* by Ward and Whipple is one of the most complete books dealing with this subject. Never having used a book like this nor done work of this kind, I was quite perplexed. That it was some kind of a crustacean seemed quite possible. That it was one of the most simply organized of the crustacea was evident. The most simply organized crustacea belong to the subclass Entomostraca. I came across the statement to the effect that the copepoda may be defined as those entomostraca which do not have a shell-like covering of the body, with four or five two-branched swimming feet on the thorax and an abdomen without appendages.[4] This statement combined with a diagram I found of the copepoda made me quite certain that I had found copepoda. I then set about to find out just what kind of a copepod it was. The copepoda are divided into two sub-orders, the Eucopepoda and the Branchiura. I found that the Eucopepoda fixed the description of my animals. They did not have compound eyes as had the Branchiura. There are two groups under the Eucopepoda, Gnathostomata and Parasita or Siphonostomata. As it was plain that my copepoda were not parasitic, they naturally fell under the group, Gnathostomata. I therefore turned to the "Key to North American Free-Swimming

[4] Ward and Whipple. *Fresh Water Biology*. J. Wiley. 1918, pp. 754–755, 742.

Copepoda" and proceeded to look under Gnathostomata. In a key of this sort one starts at the beginning and reads descriptive statements about the organism which is being classified. If the first statement read is correct, one goes on to the next statement and diagrams. If the statement is not correct, the key refers by number to the statement which is correct. By constant checking between the key and the microscope I finally decided that the animal belonged to the family Cyclopidae of which there is only one genus, the Cyclops.[5] I found the species to be Cyclops Viridis because it was the only species to be commonly found in the United States. It naturally followed that the variety was Americanus.

Following is the complete classification:

Kingdom	Animal
Sub-Kingdom	Metazoa
Branch	Arthropoda
Class	Crustacea
Sub-Class	Entomostraca
Order	Copepoda
Sub-Order	Eucopepoda
Group	Gnathostomata
Family	Cyclopidae
Genus	Cyclops
Species	Cyclops Viridis
Variety	Americanus

After doing all this involved work in Ward and Whipple, I turned to the index of the *Field Book of Ponds and Streams* and looked up "Cyclops." When I had turned to the page referred to, I was much gratified to see a picture or rather a diagram of the exact animal that I had seen under the microscope.[6] The main objection that I have to ***Fresh Water Biology*** is that it doesn't give many sketches of whole animals; it gives, mostly, no more than the separate parts in detail. Had I turned to *Field Book of Ponds and Streams* in the beginning I would have saved myself a lot of work and time. However, I feel it was a good experience to work my way through a mass of written description, and also a valuable opportunity to become acquainted with the "Keys" in the book. I now have a knowledge of the way in which to go about identifying and classifying a plant or animal.

[5] Ward and Whipple, op. cit., pp. 774, 775.
[6] Morgan, op. cit., p. 166.

The *Field Book of Ponds and Streams* gives some very interesting information concerning the cyclops.[7] There is scarcely a pond to be found without copepoda. The little water-hoppers of the genus, Cyclops, the commonest of all entomastraca (simple crustacea), are in every pond and ditch which offers them a semblance of habitation. The female has a pair of egg-packets hanging from her sides which are visible to the naked eye. I collected as many cyclops as I could find and kept them in a small beaker. After watching them for a few weeks, I noticed some larger than others. I examined these under a microscope and sure enough, I saw these egg-packets hanging from the sides. Having read that, when they are mating, the male Cyclops clasps the female with his antennae and they swim about for long periods of time during which enough sperm cells to fertilize several clutches of eggs are transferred to the body of the female, I decided to put a male and a female together under the microscope and watch the results. The male chased the female around, but in all the time I watched them, they did not come together. At a later time, however, I was fortunate enough to catch the two when they were together. I picked them out of the beaker thinking I had one, but under the microscope I could plainly see that there were two and that they were mating. I watched them patiently for over half an hour. They hadn't separated then so I proceeded to try and pry them apart with a needle, but to no avail. I finally gave up and put them into a watch glass so that I might have these two, a known male and a known female where I could observe them. Copepoda produce two kinds of eggs, summer ones which form in rapid succession and develop quickly, insuring large additions to the copepoda race; (these are the kind I found as these eggs hatched within a month and copepoda were formed) and the resting eggs usually formed in seasons of cold and drought which can lie dormant even through years of drying. The latter kind of eggs must have been in the mud that I dug up from the brook.

Copepoda eat as much of as many kinds of food as their small size will permit. They feed upon microscopic organisms, and they will devour any kind of decayed matter, but preferably decomposing plant tissue. The greatest number of copepoda are found from May to early November. It is interesting to note that Cyclops is easy to keep in an aquarium and is very useful

[7] Morgan, op. cit., pp. 166, 167.

there, being a natural food for small animals such as the brown and green hydra which flourish on it. They are also eaten by small fish.

At the same time that I was making observations of the life and habits of the copepoda, I had been examining the algae I had found in the jars. When I first made a slide of some filaments of algae, I had expected to find the sample to be all of one kind. I soon found out that this was not the case, it being almost impossible to isolate any one particular kind. Instead of one kind I had many kinds.

[NOTE: In a similar manner Mr. Sjovall proceeds to discuss how he identified a number of the different algae and diatoms which he found. As part of this presentation, the development of reproduction in algae is thoroughly discussed. As the purpose of presenting this is to illustrate a method of approach rather than to present subject matter, this portion of the paper has been omitted.

The jars Mr. Sjovall used stayed on the laboratory shelf during the summer and became quite dried. Although this particular science course is over and done for him, the college had not been open three days before I noticed fresh water had been added to the jars. Apparently sufficient interest was aroused so that he wishes to continue his observations in the field of microbiology, even though no immediate reward in terms of credits is in the offing.—O. E. UNDERHILL.]

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NEW OPERATION SAVES EYES THREATENED BY GLAUCOMA

A new operation which promises to save many eyes afflicted with glaucoma was described by Dr. Otto Barkan of San Francisco at the meeting of the American Academy of Ophthalmology and Otolaryngology at New York.

In this serious eye ailment there is increased pressure in the eyeball due chiefly to a blocking of the channels which allow for the escape of fluid from the eye back into the circulation. Dr. Barkan has perfected a method of locating the point of blockage.

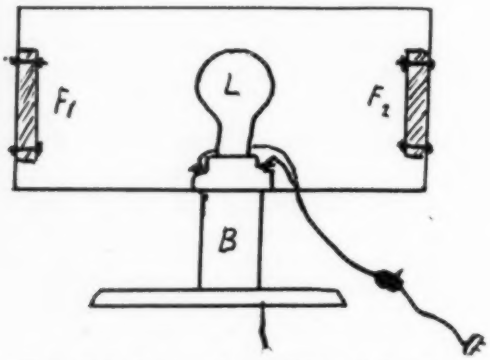
With a special lens fitted over the patient's eye and a microscopic arrangement, magnifying forty times, for both his own eyes, the surgeon is able to get a direct view of the field of operation. With a very delicate knife he then frees the clogged area at the base of the iris.

The procedure is so new that it has not been used yet on many cases, but Dr. Barkan feels that it is much superior to other operations for this condition.

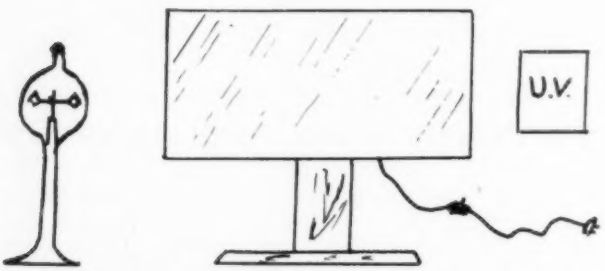
COMBINED INFRA-RED, ULTRA-VIOLET LAMPS

By Roy D. Black
Wabash High School, Wabash, Indiana

A "black light" lamp capable of supplying both infra-red and ultra-violet light can be made in an hour or so from a large coffee can, a photo-flood lamp and infra-red and ultra-violet filters. The diagram is self-explanatory. The filters required are



F 1, F 2: Infra-red and Ultra-violet filters mounted by means of strips of metal over holes cut in top and bottom of can.
L: Photo-flood lamp. B: Wooden base.



Combined Infra-red and Ultra-violet apparatus in use. The Infra-red is detected by means of a radiometer. The Ultra-violet may be shown by means of a piece of cardboard painted with a very dilute solution of primuline or aesculin.

a heat transmitting filter 3×3″ (Corning #254) and a Heat Resisting Red Purple Ultra (Corning #587) 3×3″ moulded. These filters may be obtained from nearly all apparatus dealers or from the Corning Glass Works, Corning, New York.

The unit will furnish an abundance of ultra-violet light for fluorescence demonstrations as well as enough infra-red for the usual demonstrations and for photographing small objects in absolute darkness. To photograph objects in absolute darkness, it is unnecessary to have a special camera as infra-red plates and film may be obtained for most plate camera sizes and infra-red film is now available for the 35 millimeter miniature cameras. The exposures are 20 to 30 times as long as exposures with visible light.

A few substances which fluoresce strongly are dilute solutions of quinine, primuline, eosine, fluorescein, and the minerals willemite, calcite, fluorite, the teeth and eyes and some varieties of paper also fluoresce.

The ultra-violet rays which excite fluorescence are the near ultra-violet in the region of 3900 to 3500A. These rays are supplied in abundance by the photo-flood lamps and are not stopped by the glass envelope as are the middle and extreme ultra-violet (health rays).

WHEATSTONE BRIDGE APPARATUS

By Wm. A. Harriman

Mt. Sterling High School, Mt. Sterling, Illinois

One of the most difficult experiments for the Physics student to understand is the Wheatstone Bridge. The following apparatus is easily made and has proven very helpful in the explanation of the bridge. With it the student is not only able to see what effects different size resistances have, but is also able to see the connection between the usual drawing (diamond shaped) of the bridge and the bridge.

The following material will be needed for the apparatus.

5 sockets with wood screws
4 knob insulators
4 stove bolts ($2\frac{1}{4}\times\frac{1}{4}$)
15 ft. lamp cord (double twisted)
1 male plug
6 ft. white pine ($2''\times\frac{3}{8}''$)
1 base (white pine $7\times10\times\frac{3}{4}$)
wood screws or nails

At the time of demonstration the following will be needed.

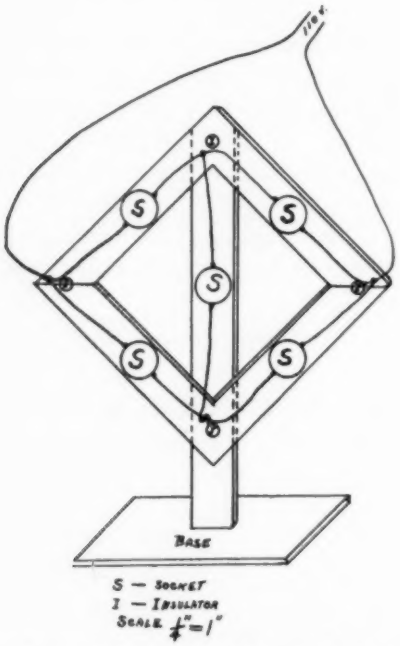
4 light bulbs all having same wattage (I use 60)
4 or 5 bulbs of different size (40 watt, 50 watt, 75 watt, and 200 watt)
Voltmeter for A.C. or D.C. current whichever is used. (If no voltmeter can be obtained use clear, low watt bulb.)

A square 12″ on each side is made of the 2″ material. Across this is nailed a diagonal of the same material which is allowed to extend 3 inches, to which

is nailed the base. At the middle of each side and the diagonal is placed one of the sockets. At each corner is an insulator. The sockets are wired in series parallel, as shown in the diagram, with the current entering at the right or left hand corner.

When demonstrated the voltmeter is attached with an extension cord to the socket on the diagonal or the clear low watt bulb is placed in the socket. The four bulbs all having the same wattage are screwed in place and the apparatus plugged into a 110V source.

The voltmeter will indicate no current flowing in the vertical branch just as a galvanometer indicates no current flowing when the bridge is balanced.



Now a smaller or larger bulb is placed in one of the sockets. The voltmeter will now indicate a current, or if a clear bulb is used it will glow indicating a current, just as the galvanometer does when the bridge is unbalanced. Also the other bulbs will change in brightness.

By placing a bulb of unknown wattage in one socket, and by matching it with bulbs of known wattage just as resistances are compared and determined, so may the wattage of the unknown be determined.

This makes a very striking and clear demonstration of an apparatus and drawing that otherwise would have been hard to understand, if understood at all.

GOLD NEAR WASHINGTON

Since gold was first discovered in Virginia in 1782 over $3,318,000 worth has been mined. The gold deposits come within a few miles of Washington at Great Falls on the Potomac River according to Dr. C. F. Park, Jr., of the U. S. Geological Survey in a report to the Virginia Geological Survey at the University of Virginia.

A GROUP DEMONSTRATION TECHNIQUE IN THE TEACHING OF GENERAL SCIENCE

By S. Joe Williams
Rolla, Missouri

In attempting to formulate a technique in the teaching of General Science, the writer is somewhat abashed at the list of well-known authorities who have made contributions to the field. However, he is impelled to add his feeble voice to the chorus of better writers by the thought that perhaps the conditions under which his plan has developed are different from the local set-up of any other contributor. The plan here described has grown out of many years of experience in teaching this particular science in small high schools where laboratory equipment is quite meager and where the classes are of both sexes and unselected as to mental ability. While it was developed in the small high school, this plan has been tried in larger schools and has proved more than adequate for the requirements in that situation. It is apparent that the plan is quite applicable to situations where teachers are asked to care for classes larger than are ordinarily handled. The technique sets itself at variance with many of the time-honored customs of science teaching but it is hoped that it has substituted procedures which are more than justified by the latest researches in psychology and by the best thought in teaching methods.

The first week of the course is taken up in getting acquainted with the pupils and allowing the pupils to become acquainted with each other. During this period the subject of the course is discussed in its most general aspects, some thought being given to the several sciences which go to make up "General Science." Reasons for the name are brought out and some of the more obvious applications of science are pointed out. In general, the way is paved for the more particular discussions which are to follow in the regular work of the course.

At about the beginning of the second week of school, a permanent class organization is effected. A class president is chosen whose duties are to organize and coordinate the work of the several groups of the class; to take charge of the class at extraordinary times; and to assign particular duties to certain groups. There is elected also, a class secretary whose duty it is to record all business of the class including the exercises assigned to the different groups. In cases where a particularly

efficient secretary is elected, even some of the class records may be entrusted to her or to someome appointed by her.

At the same time group leaders are elected, and it is the group idea which is the most distinguishing feature of this plan. It is the thing which sets this technique apart from the more orthodox methods of teaching the subject. It is the vehicle on which the class rides to such desirable destinations as socialization, pupil activity, familiarity with scientific procedures and dexterity with scientific apparatus. Enough group leaders are elected to divide the class into groups of five or six. It is best to have the leaders choose the members of their groups alternately. The reasons for this procedure are evident. It obviates a tendency to make friendship the basis of selection and it helps to distribute the talent of the class. It is quite imperative that the instructor supervise these selections to assure himself that the sexes are equally divided among the groups and that the best minds of the class do not find themselves together. These groups become the administrative units of the class. Sometimes they are named; sometimes they are numbered; and sometimes they go by the name of their leaders. Their principal duties are those connected with class demonstrations of laboratory exercises but they have other and vital functions. They alternate in taking care of class attendance and excuses. They arrange special activities of the class. They take charge of the class when routine matters are under consideration, such as reports. And, as the year progresses, they assume more and more the actual conduct of the class.

Having organized the class as noted, the pupils are ready for the more serious work of the course. If the text is not divided into units, the teacher divides it. A complete unit is assigned for reading and study, a unit which is given as much time in class as the instructor feels its importance demands. Exercises and demonstrations are filled in later. In addition to the text, the library is freely utilized. Class and individual assignments are made from this outside material, which are reported on in class. Members of the class are held responsible for these reports on the same basis as though the material covered were in their text. This forces the class to give the reports their best attention and it makes it imperative that the reporter make his report clear and accurate. There is a further lesson for the class, that of getting the most from the spoken word, a lesson not always learned in high school.

Having done the reading on the unit, that is, having made the large acquisition and having discussed the unit, the pupils are ready to further fix and improve their knowledge by exercises and demonstrations. Having learned the theory, the pupils are ready to make the applications. Aside from their value as illustrative material, the exercises aid the learning process by repeating the lessons of the text. The writer is reluctant to call the exercises of general science "experiments." That term involves working with a set of conditions toward an outcome, the exact nature of which is not accurately predictable. In our General Science we have few such problems. In most of our exercises we know what we wish to happen and we arrange our conditions so that the desired outcome is obtained. In fact, the exercise is usually considered a failure if other than the desired results eventuate. For these reasons, the writer prefers to call the exercises "demonstrations" and to treat them as such. Modern psychologists have no fault to find with the demonstration method of general science laboratory work. Often the demonstrations are given by the teacher, a custom which has the virtue of assuring the desired results but which is open to the objection that it deprives the pupils of their rightful portion of activity and at the same time robs them of even a semblance of dexterity with scientific apparatus. As already intimated, the plan of group demonstrations salvages, in part, even these more or less remote values without materially lessening the efficiency of the demonstration.

In the plan under discussion, every exercise except the few at the beginning of the course which clearly do not lend themselves to demonstration, are given by groups of pupils. These first exercises which are excluded from the list of those given in class are those which familiarize the pupils with certain fundamental scientific concept such as area, volume, space, and the relations of the English to the metric system of measurements. Obviously these must be experienced by each pupil. Other exercises, whether outlined in the text or originated by the teacher, with few exceptions lend themselves quite readily to group demonstration. As the unit is discussed, certain exercises are assigned to certain groups, who, aside from their general interest in the unit, will be particularly interested in anything which applies to their demonstration. They watch for references and material pertaining to that exercise. Each group will be eager to give a good demonstration and there arises a

wholesome rivalry between groups as each strives to excel in the presentation of its demonstration.

Some time before the exercise is to be given for the class, the group meets with the instructor to rehearse its performance. This meeting may be held before school, after school, or at any other convenient time. Once the group becomes interested in its demonstration, there will be no difficulty in getting the members to attend the group meetings. When the pupils arrive for the meeting, the instructor goes over the principle involved in their problem until every member of the group understands it thoroughly, so thoroughly in fact, that he could give an explanation of it before the class. Some member of the class is almost always given the task of making such an explanation for the class. This assignment, of course, is passed around among the members of the group. After everyone understands the principle, the instructor shows how the particular exercise applies to it and illustrates it. Then he insists that the group perform the exercise. It is needless to say that as many of the group take part in the demonstration as is possible. Once the group has successfully performed the exercise, the teacher may be reasonably assured that there will be no failure when it is given before the class. Most of our exercises in general science are so simple that once the proper conditions are set up and the desired results obtained, even pupils may arrange them again. Of particular importance in this type of demonstration is the fact that the instructor may give his undivided attention to one small group of pupils working on the exercise in contrast to the orthodox laboratory period which is often a nightmare for the instructor because of the demands made on him by a number of groups all wanting help at the same time. The one method permits of intensive work with a small group, while the other encourages a dissipation of energy with the minimum of results.

The class is prepared for the demonstration by being assigned for re-study, the principle to be demonstrated. The pupils are then in a position to ask intelligent questions about the exercise. The members of the demonstrating group come into an expectant atmosphere and give the demonstration. They know the problem; they understand it; and they are able to answer questions about it. Toward the end of the year the instructor may find himself in the enviable position of being able to sit on the side lines and direct the play while his pupils take charge of the

game. The writer admits that it is not so easy as it sounds, but it is very definitely possible. It is not only a goal, but it is an attainable goal.

Having become accustomed to appearing before the class as demonstrators, the members of the groups, which means every member of the class, feel no timidity in assuming charge of the class during discussions. And members of the class, having formed the habit of discussing demonstrations with groups who have made them, have no especial complex against thinking for themselves or against asking intelligent questions about other phases of the work. The writer believes the very fact that pupils may discuss demonstrations and scientific principles with other pupils is of decided value in encouraging self-thought and self-expression. Pupils are encouraged in every way to ask questions, and no question is left unanswered providing that it is asked in an honest effort to obtain knowledge and providing the demonstration and its accompanying discussion does not take up an unwarranted amount of time.

In the matter of notebooks, the writer can find no possible justification for general science notebooks of the type which are kept until the end of a period and then turned to the instructor for grading and criticism. In the first place, the instructor does not, and indeed, cannot do justice to the notebooks. No teacher can intelligently grade 200 notebooks, each containing a period's work in the time allotted between the handing in of the books and their return. In the second place, the practice encourages dishonesty. The best, or the most studious, or the most conscientious pupils of the class write the reports and the other pupils in the class copy them. In the third place, the knowledge gained from a demonstration should become an integral part of the child's knowledge of the subject and, as such, is no more entitled to preservation in a notebook than any other subject matter. It seems to the writer that the very fact that exercises are kept in a notebook tends to set them apart from the more academic subject matter of the course, and, instead of the exercises supplementing the work of the text, it becomes almost a different and unrelated subject.

The writer does have all pupils of the class make a written report of the demonstration. Time is allowed for it immediately following the exercise. If it appears that there will not be time, the instructor leaves the completion of the demonstration until the next day when there will be time. Furthermore, he insists

that the report be written in class and under his supervision. The report is written in such a form that it will show most readily the salient features of the demonstration. The pupil must answer such questions as, "What are we trying to prove or find out?", "What apparatus do we use?", "How do we arrange the apparatus?", and "How does the exercise prove the point?". When the class passes out, the reports are left with the teacher. He has time to look them over while the conditions of the exercise are fresh in his mind. He can easily satisfy himself of the degree of comprehension of every child and he has the opportunity to make some comment on each child's work. There are times when papers will show that certain pupils do not really understand the exercise. In such cases it may be necessary to give those pupils more time and it sometimes happens that the instructor must insist that certain pupils perform the exercise for themselves. However, once the teacher is satisfied with the work of the class on a demonstration, he hands the papers back with his comments and permits the pupils entire freedom in the disposal of the reports.

There remains the matter of testing. Frequent, teacher-made tests are to be preferred over any other type. No two science teachers have the same objectives in teaching. The very make-up of the class is a determining factor in the matter. The writer gives grades and marks in the work that he teaches. There appears to be no better way of measuring the accomplishment of his pupils. But, he is irrevocably opposed to giving any mark for work not actually done in class and under his supervision. The custom of having work done outside and brought in for a grade is to be deplored. The reasons have already been given, namely, it is difficult, if not impossible, to determine exactly whether the pupil has done the work, or has had someone do it for him. The custom of this writer is to give a short test every day or every other day on the most important points of the work and he makes no distinction between demonstration and regular class work. These tests are objective and are easily finished in five minutes. Often they are scored by pupils, a procedure which adds to the value of the test by giving the pupils the correct answers at once. The whole test even when pupils score it, seldom takes more than ten minutes. At the end of the unit a somewhat longer test is given over that unit and other pertinent material which may have a bearing on the unit. These tests are most often of the type which sets up a problem and

asks for the solution. If the policy of the school is to give semester tests, the writer welcomes the opportunity to determine how much of the work has been retained. The writer feels that at least a full 60-minute hour should be given to the general science period, and that a part of this time should be given to supervised study in class. These procedures seem to give the best results with ninth-grade pupils, who usually make up the general science class.

TEACHER, WHAT'S YOUR ANSWER?

By CHARLES H. STONE, *Boston*

Do you believe that our modern preparatory school texts in chemistry are too encyclopaedic?

Do you think that general principles are sufficiently stressed in these texts? For example, do you find in your own text book any general statement as to the preparation of ammonia? Or acids? Or neutralization?

Inasmuch as Energy is so intimately associated with chemical change, do you find that this subject is adequately treated in these texts?

Most text books defer the displacement series until well along in the year. Do you agree that this is the best plan? How do you explain, without the displacement series, why iron reacts with acid to produce hydrogen while copper does not?

Do you still teach: the LeBlanc process, the Brin process, the Deacon process? Why?

Oxygen is no longer made commercially from potassium chlorate, nor hydrogen by the action of metal on acid, nor chlorine by the oxidation of Muriatic acid. Are you justified in retaining these methods in your instruction? Why?

Would you incline to the opinion that it would be better for the beginner to work for a while with the tangible solids rather than to plunge almost at once into the preparation of the intangible gases? Why?

Do you believe in the class-room demonstration experiment? Why?

How many of these do you perform before your classes? Do you accompany each experiment with copious questioning? Why?

If you perform such demonstration experiments, do you call various pupils to the desk to assist you? What advantage do you find in this?

Should the laboratory exercise follow or precede the lesson? Why?

Is the teacher justified in performing as a demonstration the same experiment which is later to be done in the laboratory by the student? If so, to what extent would you favor this method?

Do you accept in the recitation "Yes" and "No" answers, parts of sentences, or single words in response to questions asked the pupil? Why?

To what extent do you attempt to correlate your subject with the other science subjects in the curriculum? Do you think it is a good idea to do this?

Do you insist that your students shall from time to time make drawings of the apparatus shown on the desk or used in the laboratory? Why?

Do you waste time each day when taking attendance by calling the roll? Is it not possible to seat your class so that a glance will show who is absent?

Do you ask leading questions, questions which indicate their own answer, questions which can be answered by "Yes" or "No"?

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solutions.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

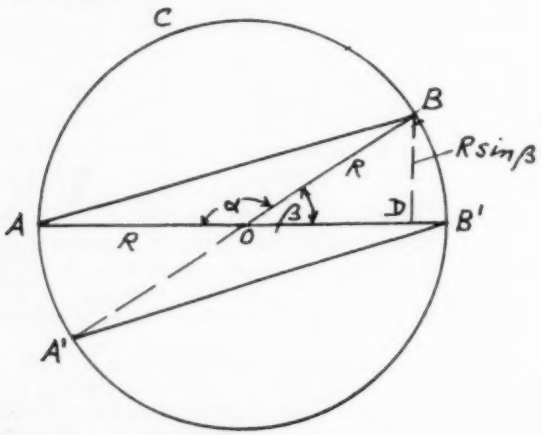
1440, 1449, 1450, 1452. *Daniel Finkel, New York.*

1448, 1449, 1453. *Isadore Chertoff, Bayonne, New Jersey.*

1454. *Proposed by Hugo Brandt, Chicago.*

Divide a circle by two parallel lines into three parts of equal area.

Solution by the proposer.



Let AB and $A'B'$ be the required parallels, with α, the angle subtended at the center by AB. Now segment ABC = Sector $AOBCA - \triangle AOB$. This gives the equation

(1) $\frac{1}{2}R^2\pi = (R^2\alpha)/2 - R^2/2 \sin\alpha$ or

(2) $\alpha - \sin\alpha = \frac{1}{3}\pi = 2.09439+.$

To solve this transcendental equation by a method of approximation, assume a rectangle formed by AB, $A'B'$ and the tangents to the circle perpendicular to the parallel lines. Let the area of the rectangle be $\frac{1}{3}\pi R^2$. If, h, be the altitude on AB, then the area is $2Rh$, or $2Rh = \frac{1}{3}R^2\pi$ from which $h = R\pi/6$. But $h/2R = \sin\beta/2$. Hence

$$\text{Sin}\,\frac{\beta}{2} = \frac{R\pi}{12R} = \frac{\pi}{12} = .2618 \text{ (approx.)}$$

$$\therefore \frac{\beta}{2} = 15°10'36'' \text{ which gives}$$

$$\beta = 30°21'12'' \text{ and}$$

$$\alpha = 149°38'48'' \text{ (1st approx.)}$$

To get a closer approximation, assume

$$149° < \alpha < 150°.$$

From this we shall find α-sin α as follows:

$$\alpha = 149° = 2.60054, \quad \alpha = 150° = 2.61799$$

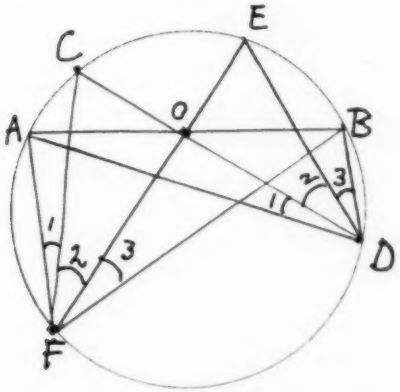
$$\sin\alpha = .51504, \quad \sin\alpha = .50000.$$

Hence α-sin $\alpha = 2.08550$ and $= 2.11799$. Since the given value of α-sin α from (2) is 2.09439, α is seen to lie between 149° and 150°. Interpolating for minutes we find α between 149°16′ and 149°17′. By a similar method if we assume $149°16' < \alpha < 149°17'$, we obtain α-sin $\alpha = 2.09415$ and 2.09470 and by interpolating for seconds we find $\alpha = 149°16'26''.2$.

Solutions were also offered by W. E. Buker and H. R. Mutsh, Glen Rock, Pa.

1455. *Proposed by D. McLeod, Winnipeg, Canada.*

In a circle, AB is any chord with O its midpoint. EOF and COD are any other chords. If ED cuts AB in x and CF cuts AB in y, prove $OX = OY$.



Solution by Isadore Chertoff, Bayonne, N. J.

Join F to A, and D to B. Since the angles from F and D are equal as indicated, the anharmonic ratios $F-(AOYB)=D-(BOXA)$. This equality becomes

$$\frac{AY}{OY}\cdot\frac{OB}{AB}=\frac{BX}{XO}\cdot\frac{AO}{AB}.$$

Since $AO=OB$ it reduces to $\frac{AY}{OY}=\frac{BX}{XO}$, which by addition of 1 to both members becomes $\frac{AO}{OY}=\frac{OB}{XO}$. $\therefore OY=XO$.

A solution was also offered by A. R. Haynes.

EDITORS NOTE: This problem was formerly proposed as 1265 with a solution appearing in the November issue of 1933.

1456. *Proposed by Isadore Chertoff, Bayonne, N. J.*

If $ax^2+bx+c=0$, the six equations that can be formed by interchanging the coefficients will have rational roots if $a+b+c=0$.

Solution by G. S. N. Ayyar, Tiruvilwamala, Cochin State, India

For the roots of a quadratic equation to be rational, the discriminant must be a perfect square.

Since $a+b+c=0$, then $b^2-4ac=(a+c)^2-4ac$

$$=(a-c)^2$$

$\therefore ax^2+bx+c=0$ will have rational roots. Similarly the other five equations will also have rational roots, the discriminants being $(a-b)^2$, $(b-c)^2$, etc.

Solutions were also offered by Charles W. Trigg, Los Angeles, Bernard Leventhal, New York, Max Fowler, University of Illinois, H. R. Mutch, Glen Rock, Pa., Samuel H. Barkan, Brooklyn, N. Y., W. E. Buker, Leetsdale, Pa., David Blackwell, University of Illinois, and the proposer.

1457. *Proposed by the Algebra IV class of the Lewis and Clark High School, Spokane, Washington.*

A man received a check for a certain number of dollars and a certain number of cents. The person cashing it for him gave him a number of dollars equal to the number of cents he should have received and a number of cents equal to the number of dollars he should have received. He spent \$3 and then found he still had three times the amount of money the check called for in the first place. For what amount was the check written?

Solution by proposer and the teacher, Miss Kate Bell.

Let x = the number of dollars called for by the check.

y = the number of cents called for by the check.

$100x+y$ = the value of the check in cents.

$100y+x$ = the cash he received in cents.

$$100y+x-300=3(100x+y) \tag{1}$$

$$97y-300=299x \tag{2}$$

$$y=\frac{299x+300}{97}=3x+3+\frac{8x+9}{97}. \tag{3}$$

$$\text{Set } a=\frac{8x+9}{97}, \text{ then } x=\frac{97a-9}{8}=12a-1+\frac{a-1}{8}. \tag{4}$$

$$\text{Set } k=\frac{a-1}{8} \text{ then } a=8k+1.$$

Substituting in (4)

$$x=12(8k+1)-1+\frac{(8k+1)-1}{8}=97k+11. \tag{5}$$

Take $k=0$

then $x=11$ and

$$y=\frac{(299)\ (11)+300}{97} \text{ or } y=37.$$

Hence \$11.37 is the amount of check.

Note:

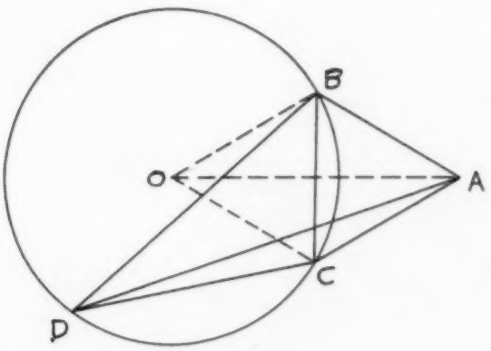
If $k=1$ then $x=108$ and $y=336$. \$108.00+336 cents=\$111.36.

It would seem that any value of k could be used giving this interpretation but the one above is the desired one.

Solutions were also offered by G. S. N. Ayyar, India, David Blackwell, University of Illinois, Max Fowler, University of Illinois, A. R. Haynes, Hobson M. Zerbe, W. E. Buker, Leetsdale, Pa., Glen F. Hewitt, Chicago, Isadore Chertoff, Bayonne, N. J., Harold B. Friedman, Atlanta, Ga., W. R. Smith, Chicago, Charles W. Trigg, Los Angeles, G. R. Rary, Sioux City, Iowa, D. F. Wallace, Herman O. Makey, Fort Wayne, Ind., David Rappaport, Chicago, H. R. Mutch, Glen Rock, Pa., and Bernard Leventhal, Brooklyn.

1458. *Proposed by D. P. Wallace, Minnesota.*

BC, the chord of a circle equal to its radius, is one side of an equilateral triangle whose other vertex A is outside the circle. Show, if D is any point on the circle, $\overline{AD}^2=\overline{BD}^2+\overline{CD}^2$.



First Solution

By Charles W. Trigg, Cumnock College, Los Angeles.

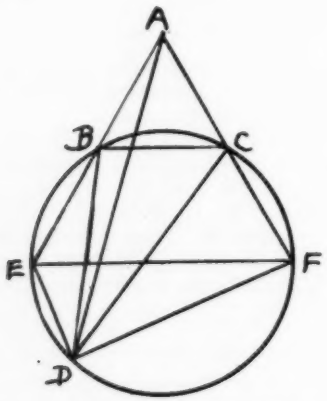
Draw the radii OB, OC, OD, and draw OA. Then $AB=BC=AC=OB=OC=OD=r$. $AO=r\sqrt{3}$. $\angle BOC=60°$, $\angle AOC=30°$, $\angle COD=\theta$.

In $\triangle COD$, $\overline{CD}^2 = \overline{OC}^2 + \overline{OD}^2 - 2 \cdot OC \cdot OD \cos\theta$
$= 2r^2 - 2r^2 \cos\theta.$
In $\triangle BOD$, $\overline{BD}^2 = \overline{OB}^2 + \overline{OD}^2 - 2 \cdot OB \cdot OD \cos(\theta + 60°)$
$= 2r^2 - 2r^2(\frac{1}{2}\cos\theta - \frac{1}{2}\sqrt{3}\sin\theta).$
Adding, $\overline{BD}^2 + \overline{CD}^2 = r^2(4 - 3\cos\theta + \sqrt{3}\sin\theta).$
In $\triangle AOD$, $\overline{AD}^2 = \overline{AO}^2 + \overline{OD}^2 - 2AO \cdot OD \cos(\theta + 30°)$
$= 4r^2 - 2\sqrt{3}r^2(\frac{1}{2}\sqrt{3}\cos\theta - \frac{1}{2}\sin\theta)$
$= r^2(4 - 3\cos\theta + \sqrt{3}\sin\theta).$
$\therefore \overline{AD}^2 = \overline{BD}^2 + \overline{CD}^2.$

Second Solution

By D. F. Wallace.

Produce AB and AC to meet the circle again respectively at E and F. Draw EF, ED and FD.



Since angles ABC and $ACB = 60°$ each, $\angle EBC = \angle FCB = 120°$.
Therefore arcs EBC and FCB are arcs of 120° each.
Arc $BC = 60°$ (since chord BC is equal to the radius of the circle).
Therefore arc BE = arc $CF = 60°$.
Therefore arc $EBCF = 180°$ and EF is a diameter of the circle.
Also, $AB = BE = AC = CF$
Because B is the midpoint of AE and C is the midpoint of AF:

$$AD^2 + ED^2 = 2AB^2 + 2BD^2 \quad (1)$$

$$AD^2 + FD^2 = 2AC^2 + 2CD^2 \quad (2)$$

Adding (1) and (2), we have

$$2AD^2 + ED^2 + FD^2 = 2AB^2 + 2AC^2 + 2BD^2 + 2CD^2 \quad (3)$$

$ED^2 + FD^2 = EF^2 = 4AB^2$ and $2AC^2 = 2AB^2$.

Therefore

$$2AD^2 + 4AB^2 = 4AB^2 + 2BD^2 + 2CD^2 \quad (4)$$

Subtracting $4AB^2$ from both members of (4) and dividing the remainder by 2, we have

$$AD^2 = BD^2 + CD^2 \qquad Q\ E\ D$$

Solutions were also offered by A. R. Haynes, Tacoma, Wash., G. S. N. Ayyar, India, Walter R. Warne, University Heights, New York City,

Isadore Chertoff Bayonne, N. J., Bernard Leventhal, Brooklyn, N. Y., Samuel H. Barkan, Brooklyn, N. Y., W. E. Buker, Leetsdale, Pa., and Aaron Buchman, Buffalo, N. Y.

1459. *Proposed by Cecil B. Read, University of Wichita, Kansas.*

The area of a quadrilateral which can be both inscribed in a circle and circumscribed about another circle is $\sqrt{abcd}$.

Solution by the proposer.

The area of a quadrilateral which is inscribable in a circle is given by the formula $\sqrt{(s-a)(s-b)(s-c)(s-d)}$ (Johnson, Modern Geometry, p. 81, or this magazine, June, 1935, p. 651).

If the sides AB, BC, CD, and DA are tangent at P, Q, R, and S respectively, we obtain

$$AP=AS,\ BP=BQ,\ CQ=CR,\ DR=DS$$

and

$$AP+BP+CR+DR=AS+BQ+CQ+DS$$

$$AB+CD=BC+DA$$

or

$$a+c=b+d.$$

Since $s=\frac{1}{2}(a+b+c+d)$, we have $s=a+c=b+d$.

Hence $s-a=c$; $s-b=d$, $s-c=a$, and $s-d=b$.

Substituting these values in the above formula, we have Area $=\sqrt{abcd}$.

Solutions also offered by Charles W. Trigg, Los Angeles, A. R. Haynes, Samuel H. Barkan, Brooklyn, N. Y., Aaron Buchman, Buffalo, N. Y., Isadore Chertoff, Bayonne, N. J., Walter R. Warne, New York City, G. S. N. Ayyar, Tiruvilwamala, Cochin State, India, W. E. Buker, Leetsdale, Pa., and Bernard Leventhal, Brooklyn, N. Y.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

No names for this issue.

PROBLEMS FOR SOLUTION

1472. *Proposed by Aaron Buchman, Buffalo, New York.*

Given triangles ABC and DEF, with fixed point D' on AB. Construct triangle $D'E'F'$ similar to DEF so that E' is on BC and F' on CA.

1473. *Proposed by Nathan Altshiller-Court, University of Oklahoma.*

The sum of the diagonals of a parallelopiped is smaller than one half and greater than one third of the sum of the diagonals of its faces.

1474. *Proposed by G. S. N. Ayyar, India.*

$ABCD$ is a quadrilateral with sides AB, BC, CD, and DA divided by P, Q, R, S, respectively so that ratios $PA:PB=QB:QC=RC:RD=SD:SH=m:n$. Find the area of the quadrilateral $PQRS$ in terms of m and n, and the area, K, of $ABCD$.

1475. *Proposed by Charles W. Trigg, Los Angeles.*

In an inscriptable convex quadrilateral the diagonals are to each other

as the products of the sines of one-half the angles non-adjacent to the diagonals.

1476. *Proposed by G. S. N. Ayyar, India.*

One circle is inside another. A chord of the outer circle touches the inner circle in P and cuts their radical axis in Q. Show that $AQ:BQ = \overline{AP}^2:\overline{PB}^2$.

1477. *Proposed by A. T. McGregor, Elk Grove, California.*

A certain number is the product of three prime factors, the sum of whose squares is 2331. There are 7560 numbers (including unity) which are less than the number and prime to it. The sum of its divisors (including unity and the number itself) is 10560. Find the number.

SCIENCE QUESTIONS

December, 1936

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Readers of School Science and Mathematics are asked to contribute: Questions, Answers, Comments, Suggestions—Whatever is new or interesting in the teaching of Science.

Your classes and yourself are invited to join the GQRA (Guild Question Raisers and Answerers). More than 100 others have already been admitted to membership by answering a question or proposing one that is published.

LET'S TRADE

SCIENCE QUESTIONS is proposing a trade between PROBLEM DEPARTMENT (Mathematics) and our Department (Science).

We are sorry that there is not time to correspond with your Editor—Professor G. H. Jamison—and ask him what he thinks about it first and so here goes in this issue with a question or two that are partway or beyond the borderline of our departments. When something good is sent in to Science Questions Editor and there is not time to shoot it along to Mathematics Problem Department, it may creep into our copy and we ask you to do the same with any good Science Question that is on the borderline or beyond.

Are we agreed? Is it a good thing? I'll leave it up to the readers to send in their comments and answers. Future conduct will be governed accordingly.

ANYTHING THUS PUBLISHED WILL ENTITLE THE PROPOSER, OR ANSWERER, TO MEMBERSHIP IN THE GQRA (Guild Question Raisers and Answerers). ONE HUNDRED AND FIFTY TWO (152) others have become members.

JOIN THE GQRA

TRADE NUMBER ONE

771. *Proposed by Tully F. Watson, Northeastern Teachers College, Tahlequah, Oklahoma. (Elected to the GQRA, No. 163)*

The minimum force required to slide a mass (m) at constant velocity up an inclined plane of inclination A is of magnitude

$$\frac{mg}{\sqrt{1+n^2}}[n \cos A + \sin A]$$

and it makes an angle B with the inclined plane, where $\tan B = n$. n is the coefficient of kinetic friction between the mass and the plane.

TRADE NUMBER TWO

773. *Proposed through a pupil of Brother Felix John (GQRA No. 17), Catholic High School, Pittsburgh, Pa. who will be Elected to the GQRA, No. 154, when his name is sent in.*

"A youngster culled the following "teaser" from some detective magazine and gave it to me the other day. I think he said it was in the November issue of *Black Mask* in a story called *A Man Had A $1,000.*

Here it is:

A "guy" had a thousand dollars and ten bags. How shall he distribute the money in the ten bags so that he can give out any amount in dollars from one to a thousand without having to take any money out of any of the bags?

QUESTIONS FROM CONSUMERS RESEARCH

774. *From circulars of Consumers Research*

1. What common foods contain lead or arsenic, or both, in dangerous amounts?
2. What items should a home medicine chest contain?
3. Are (?)'s claims for grape juice as a fat reducer truthful?
4. Should the consumer eat oranges that have been dyed or ripened with ethylene gas?
5. (Not from CR) Is it true that the juice of oranges that have been frosted is poisonous?
6. Is it safe to use a sulphide depilatory like (?) on the face?
7. What are vitamins, how necessary are they, and what foods contain them?
8. Are vanishing creams irritating to the skin?

(Pupils or teachers will be elected to the GQRA for satisfactory answers to one or more of the parts in question 773.)

ELEMENTARY UNIVERSES

775. *Extract from a six-sheet invitation to join in the development of the properties of elementary self-contained universes issued by E. M. Tingley, 221 N. Cuyler Avenue, Oak Park, Ill. Mr. Tingley will be elected to the GQRA provided he will put some of his questions in suitable form for publication in this Department.*

Quotation—"If internal motion ceases, time ceases, and the universe becomes dead. Inertia or continuance of motion, is therefore a necessary and inherent property of time and length in a live world, even of three points, and inertia admits of no farther definition."

What do you think about it?

---

767. *Proposed by Glenn F. Hewitt, Von Steuben High School, Chicago Ill. (GQRA No. 151).*

What is peculiar or odd in the following story:

"One hot afternoon in August, a group of ladies were playing bridge. Near the end of the afternoon, the husband of one of the ladies arrived to take his wife home in the car. She told him they would leave as soon as they finished the hand they were playing, so he sat down in a chair outside on the front porch to wait. As it was a very hot afternoon and he had had a tiresome day at the office, he became drowsy sitting there with no one to talk to and he very soon dozed off. He began to dream a vivid dream. He seemed to see himself back in the days of the French Revolution. Riot and confusion were everywhere. Ahead of him he saw the guillotine, and saw victim after victim being led up to its voracious jaws, and heard a new shout go up at the sight of each new sacrifice and a greater shout as each head fell. Suddenly he realized with horror that he himself was in the lineup of victims! All too soon the line ahead of him passed up and on into Eternity, and now it was his turn. He was placed in a kneeling position before the machine, the signal was given to release the blade, and the knife started down with a rush.

"Just at this point in his dream, the ladies emerged chattering from the house, and his wife, noticing her husband asleep in his chair, gently tapped him on the neck with her glove to awaken him. The tap on the neck came just at the precise instant in his dream when the guillotine blade had reached his neck. The shock to his nervous system was so great that he fell off his chair—dead."

What is *your* answer?

(The answer hidden under a sealed slip was "How did anyone know what he was dreaming about?")

Answer by Maxwell O. Reade (GQRA, No. 48) 45 Perkins Hall, Harvard University, Cambridge, Mass.

As far as the "think" problem is concerned—it's quite possible that the objection raised—how the lady did know what her husband was dreaming of may not be valid. It is conceivable that an outsider might know the content of someone else's dream—though as far as I know quite a remote possibility. If this were true—it is also possible that a heart attack, resulting from the fear, might have been the immediate cause of the sleeper's death.

I'd like a positive opinion—perhaps from one of the other members—on the above.

Chemistry Final. Second Semester 1936

776. *Submitted by Leo R. Spogen (GQRA, No. 64), Red Lodge, Mont.*

Part I—60 points

Ionize the following:

1. $FeCl_3$
2. $Al_2(SO_4)_3$
3. H_2SO_4

Write the Formulae for the following:

4. limestone
5. ferric hydroxide
6. octane
7. phosphate rock
8. baking soda
9. galena

10. A solution of $CuSO_4$ would turn _____ litmus _____.
11. The dark lines in the solar spectrum are called _____.
12. Aqua regia is a mixture of _____ and the _____ produced will dissolve gold.
13. The chemicals used in testing for the nitrate radical _____ _____.
14. The flame test for Cu _____, Calcium _____ _____, Sodium _____, Potassium _____ _____.
15. The valence of the atom with atomic number seven is _____.
16. Write formulae of chemicals causing temporary hardness _____ _____.
17. How could you free the bromine from NaBr? Add _____.
18. Name one element that Mendelejeff predicted by his periodic table that was as he said it would be _____.
19. Heavy water contains the _____ atoms.
20. Name three methods for the fixation of Nitrogen, 1. _____ _____, 2. _____, 3. _____.
21. Corn starch is changed to Karo by _____.
22. Nitro celluloses are made by the action of _____ and_____on cellulose.
23. Glycerine is a by-product from the manufacture of _____.
24. Give an example of isomers _____.
25. Cooking potatoes makes them more digestible because _____ _____.
26. Give the per cent of carbon in cast iron _____, steel _____, and wrought iron _____.
27. What enzyme changes sugar to alcohol _____.
    What enzyme changes starch to sugar _____.
28. Changing from a higher valence to a lower valence is called _____ _____.
29. Thermite is a mixture of _____ used in welding.
30. Diagram the atom of atomic number ten.
    The number of _____ determines the atomic weight and the _____ determines its chemical behavior.

Part II—40 points

Chemistry Final Second Semester Part 2.

Value ten points for each.

1.

List five vitamins and the disease an insufficiency of each causes.

2.

Write the chemical reaction that takes place in a blast furnace when iron ore is smelted.

Write the reaction for making slacked lime.

Write a reaction showing neutralization.

3.

Explain why the chemistry of carbon is more extensive than that of any other atom.

4.

How many liters of carbon dioxide result from the fermentation of 60 grams of glucose.

$$\underset{C-12}{C_6H_{12}O_6} = \underset{H-1}{2C_2H_5OH} + \underset{O-16}{2CO_2}$$

BOOKS RECEIVED

Science, by Ira C. Davis, Head of Department of Science, University High School, Assistant Professor in the Teaching of Science, School of Education, University of Wisconsin, and Richard W. Sharpe, Formerly Professor of Biology, State Normal School, River Falls, Wisconsin, and Instructor in Science, George Washington High School, New York City. Cloth. Pages xi+491. 15×23.5 cm. 1936. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.72.

Descriptive Physics, by Sherman R. Wilson, Head of the Exact Science Department, Northwestern High School, Detroit, Michigan. Cloth. ix+231. 13×19.5 cm. 1936. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.20.

Recent Advances in Physical Chemistry, by Samuel Glasstone, Lecturer in Physical Chemistry at the University of Sheffield. Third Edition. Cloth. Pages viii+477. 13×20 cm. 1936. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $5.00.

Recent Advances in General Chemistry, by Samuel Glasstone, Lecturer in physical Chemistry at the University of Sheffield. Cloth. Pages ix+430. 13×20 cm. 1936. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $5.00.

Business Mathematics, by Lucien Blair Kinney, Chairman, Department of Mathematics, University of Minnesota High School, and Instructor, College of Education, University of Minnesota. Cloth. Pages vii+350. 13.5×20 cm. 1936. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.40.

A Textbook of Organic Chemistry for Students of the Medical Sciences, by Hugh C. Muldoon, Professor of Chemistry and Dean of the School of Pharmacy, Duquesne University. Second Edition. Cloth. Pages xv+590. 13.5×20.5 cm. 1936. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $3.00.

Handbook of Chemistry and Physics, edited by Charles D. Hodgman, Associate Professor of Physics of Case School of Applied Science. Twenty-first Edition. Cloth. Pages xviii+2028. 10.5×16.5 cm. 1936. The Chemical Rubber Company, 1900 W. 112th Street, Cleveland, Ohio. Price $6.00.

Plane and Spherical Trigonometry, by J. Shibli, The Pennsylvania State College. New Edition. Cloth. Pages xii+242+ii+94. 14×21 cm. 1936. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.96.

Electricity and Magnetism for Engineering Students, by A. W. Hirst, Chief Lecturer in Electrical Engineering College of Technology, Leicester. Cloth. Pages xv+388. 14.5×22 cm. 1936. Messrs. Blackie and Son, Limited, 50 Old Bailey, London, E.C.4. Price 15s. net.

Properties of Matter, by F. C. Champion, Lecturer in Physics, University of London (King's College) and N. Davy Senior Lecturer in Physics, University College, Nottingham. Cloth. Pages xiv+296. 14.5×22 cm. 1936. Messrs. Blackie and Son, Limited, 50 Old Bailey, London, E.C.4. Price 15s. net.

Unit-Plan Workbook for First-Year Algebra, by Virginia Willett, Principal and Head of Department of Mathematics, Elizabethtown High School, Elizabethtown, Kentucky. Paper. 120 pages. 21×28 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 48 cents.

Modern Chemistry, by Charles E. Dull, Head of Science Department, West Side High School and Supervisor of Science for the Junior and Senior High Schools, Newark, N. J. Cloth. Pages xii+745+xxxii. 12×19 cm. 1936. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.80.

Radio Field Service Data, by Alfred A. Ghirardi. Second Revised Edition. Cloth. Pages x+436. Loose Leaf. 14×20.5 cm. 1936. Radio and Technical Publishing Company, 45 Astor Place, New York, N. Y. Price $2.50.

Our Natural Resources and Their Conservation, by A. E. Parkins, George Peabody College for Teachers, and J. R. Whitaker, University of Wisconsin as Editors. Cloth. Pages xii+650. 14.5×23 cm. 1936. John Wiley and Sons, Inc., 440 4th Avenue, New York, N. Y. Price $4.00.

BOOK REVIEWS

College Zoology, by Robert W. Hegner, Professor of Protozoology in the School of Hygiene and Public Health of the Johns Hopkins University. Fourth Edition. Cloth. Pages xvi+742. 14×22 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

Among those trained in zoology in this country during the last twenty-five years, perhaps no book is better known than *Hegner*. The first edition appeared in 1912, with revisions in 1926, 1931, and 1936. Through all the editions one is impressed by the faithful adherence of the author to his original plan. As to this plan we quote from the preface:

"This book is arranged so that the student learns where each animal belongs in the animal kingdom; its characteristics and those of the other animals in its class or phylum. One common native species is generally used as a type of each large group and then the classification and characteristics of other members of the group are presented more briefly. The groups in the animal kingdom are considered approximately in order of their supposed evolution and thus biological facts and theories fall into an ascending series from the comparatively simple to the more complex. In each group the fundamental biological, subjects are studied,—morphology, physiology, behavior, reproduction, embryology, classification, geographical distribution, evolution, paleontology,—thus furnishing the data from which the student arrives at generalizations. Various biological phenomena are particularly emphasized in connection with the group of animals that furnishes the best illustrative material. . . . Various other biological facts and theories are presented in special chapters. . . ."

Some noteworthy changes in the 1936 edition are: (1) increased attention to Parasitism involving the addition of a chapter on "Relations of Protozoa to Man," and a chapter on "Parasitism in Animals"; (2) the substitution of the grasshopper for the honey bee as an insect type; (3) the revision and extension of the section on the frog, with the addition of a number of original figures; and (4) the large number of new illustrations (including many fine original ones) all through the book. Among the new figures, a series of illustrated genealogical trees will prove especially helpful in visualizing the evolution of animals.

Although the number of pages has been increased by twenty-nine, the thickness of the book has actually been decreased by about one-third. This decrease is a doubtful gain, however, since it results from using a thinner, translucent paper, making type and figures visible through the sheet. This could easily be remedied in subsequent printings.

As in previous editions, the phylum Chordata is given almost as much space as all other phyla combined; the result is a work having considerable usefulness in courses in vertebrate zoology.

The book is so full of valuable information that it is entitled to a place in every college library and in every laboratory of beginning zoology.

EDWARD C. COLIN

The New Champlin Cyclopedia for Young Folks, Science and Invention, edited by George Moreby Acklom. Cloth. Volume I, iv+508 pages. Volume II, 492 pages. 16×23 cm. 1936. Henry Holt and Company, One Park Avenue, New York, N. Y. Price $5.00 per volume.

These two volumes form Vol. V and Vol. VI of *The New Champlin Cylcopedia for Young Folks*. They are compiled especially for young people in the upper grades and high school but will be interesting and instructive to every member of the family. It cannot be expected that every word connected with the progress of science and the practical applications of science to industry and art will be given a very elaborate presentation in two volumes but one is most agreeably surprised at the breadth of subject matter and thoroughness of the treatment.

The historical method of approach is frequently used as, e.g., in the discussion of "books." A brief sketch of the earliest books of clay and papyrus is followed by a longer account of the modern methods of book making. In a work compiled from so many sources it is not to be expected that it will be entirely free from errors or at least from sentences which may admit incorrect interpretations. Examples are to be found in the article on "radio" where we are informed that varying the number of turns used in a coil varies the *resistance* whereas the variation in *inductance* is the important change; or in the article on "atomic numbers" we are taught that the "chemical properties [of chlorine] depend upon the number of the electrons and not on their arrangement"; in the article on "acoustics" the author lists among other things, stretched wires as effective in reducing reverberation. But such instances are exceptions rather than the rule. In general the discussions are reliable, easily understood, instructive, and interesting. The author has shown unusual ability to select the essentials and to distinguish between theory and fact. These substantially bound and well illustrated books are worthy of a place in home or school library.

G. W. W.

Getting Acquainted with Minerals, by George Letchworth English, Consulting Mineralogist. Cloth. Pages xi+324. 14.5×23 cm. 1934. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.50.

Fifty years devoted to the study of minerals is the preparation made by the author for writing this book. And it is a truly wonderful little book—just the thing for the beginning student who wants to learn to identify or collect minerals for the pleasure of knowing the beautiful forms of the mineral kingdom. It also has much for the student with a more practical aim, because attention is also paid to the uses and occurrence of minerals of commercial value, especially those found in the United States.

The first part of the book is an explanation of the general properties of minerals. Here is given the physical properties used for identification; what minerals are made of; how to collect them; and several short chapters on crystals. The interesting style of the author is indicated by some of the chapter headings, such as "The Pranks of Crystals," "Mineral Mimics," "Black Light and Other Color Phenomena."

The second part is a description of minerals. They are grouped on the basis of the most important element in their composition and are arranged alphabetically. The third part gives a brief description of the rocks of the earth. Finally there is appended a key for the identification of minerals, and a pronouncing vocabulary. The language used is simple and clear, the subject matter is scientifically accurate. Two hundred and fifty-seven pictures and drawings adorn the book, and it is provided with an excellent

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LIPPINCOTT Chicago-Philadelphia

index which enables one at a glance to determine what it contains and where to find it.

G. W. W.

Elementary Photography, for Club and Home Use, by C. B. Neblette, and Frederick W. Brehm, both of the Department of Photographic Technology, Rochester Athenaeum and Mechanics Institute, and Everett L. Priest, Principal, Rensselaer Falls High School, Rensselaer Falls, New York. Cloth. Pages viii+253. 13.5×20 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 72 cents.

This is a manual of photography written especially for junior and senior high school pupils. A knowledge of physics and chemistry is not necessary because emphasis is placed on the art of photographic processes rather than on the theory. The discussion begins with the simplest type of photography—taking a picture with a pinhole camera. Directions are given for making the camera, loading it, selecting a subject, making the exposure, developing the film, making the print, and mounting.

In the second part a brief explanation is given of the chemistry and physics of photography. Just enough about lenses is given to explain the necessity for proper focus and the importance of a good lens. Instructions are then given in handling the camera, preparation of solutions, the theory and practice of developing the printing. Other topics discussed are making enlargements and lantern slides, indoor photography, night photography, and making photomicrographs. This is an excellent manual for the amateur photographer.

G. W. W.

295 American Birds, Ninety-two Color Plates from "Bird Portraits in Color," by Thomas S. Roberts. Spiral Binding, and Hard Covers. 20.5×27.5 cm. 1934. The University of Minnesota Press, Minneapolis, Minnesota. Price $2.00.

These color plates are reproductions of great paintings by Allan Brooks, George Miksch Sutton, Walter Alois Weber, Francis Lee Jaques, Walter John Breckenridge, and Louis Agassiz Fuertes.

The reproductions are themselves real works of art, and tell more about the appearance and even the lives and habits of our American birds than could be given by many pages of descriptive matter. The wire spiral binding permits each plate to be exposed flat. Every bird lover should have a copy of these plates.

G. W. W.

Handbook of the Heavens, Sponsored by The American Museum of Natural History. Edited by Hubert J. Bernhard, Director of Publications, Junior Astronomy Club; Dorothy A. Bennett, Assistant Curator of the Hayden Planetarium, Adviser, Junior Astronomy Club; and Hugh S. Rice, Associate in Astronomy, American Museum, Scientific Associate, Junior Astronomy Club. Cloth. Pages xvi+131. 15×23 cm. 1935. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $1.00.

The contributors to this book are the members of the Junior Astronomy Club of the Museum of National History, New York. It is a handbook and manual for amateur astronomers. Included with the discussions are many excellent full-page star charts, instructive diagrams, and good photographs. No other book in this field contains so much for a dollar.

G. W. W.

THE MULTIFOLIATE MONOGRAPHS

Third Discourse on Collective Numbers by Robert A. Philip

Equations in Synthetic Numbers

The formula for the product of two compound numbers:

$$(2 \;\&\; 3) \times (3 \;\&\; 5) = 6 \;\&\; 15$$

may be changed into an equation of the first degree in $(X \;\&\; Y)$ by substituting this unknown quantity for one of the factors, say $(3 \;\&\; 5)$, and then:

$$(2 \;\&\; 3)\ (X \;\&\; Y) - (6 \;\&\; 15) = O \;\&\; O$$

This equation of the first degree in compound numbers has the singular solution:

$$X \;\&\; Y = (6 \;\&\; 15)/(2 \;\&\; 3) = 3 \;\&\; 5$$

An equation of the second degree in compound numbers may be formed from two factors of the first degree:

$$[\ (X \;\&\; Y) - (3 \;\&\; 2)\ ]\ \ [\ (X \;\&\; Y) - (4 \;\&\; 5)\ ] = O \;\&\; O$$

or

$$(X \;\&\; Y)^2 - (7 \;\&\; 7)\ (X \;\&\; Y) + (12 \;\&\; 10) = O \;\&\; O$$

This equation has also the alternative factors:

$$[\ (X \;\&\; Y) - (3 \;\&\; 5)\ ]\ \ [\ (X \;\&\; Y) - (4 \;\&\; 2)\ ] = O \;\&\; O$$

The two sets of factors determine the four roots of the equation:

$$(X \;\&\; Y) = (3 \;\&\; 2) \text{ or } (4 \;\&\; 5) \text{ or } (3 \;\&\; 5) \text{ or } (4 \;\&\; 2)$$

An equation of the third degree in compound numbers may be formed from three factors of the first degree:

$$[\ (X \;\&\; Y - (3 \;\&\; 2)\ ]\ \ [\ (X \;\&\; Y) - (4 \;\&\; 5)\ ]\ \ [\ (X \;\&\; Y) - (1 \;\&\; 6)\ ] = O \;\&\; O$$

or

$$(X \;\&\; Y)^3 - (8 \;\&\; 13)\ (X \;\&\; Y)^2 + (19 \;\&\; 52)\ (X \;\&\; Y) - (12 \;\&\; 60) = O \;\&\; O$$

This equation has also five other sets of alternative factors. The six sets of factors are formed from the nine roots of the equation:

$$(X \;\&\; Y) = (3 \;\&\; 2) \text{ or } (4 \;\&\; 5) \text{ or } (1 \;\&\; 6) \text{ or}$$
$$(3 \;\&\; 5) \text{ or } (4 \;\&\; 6) \text{ or } (1 \;\&\; 2) \text{ or}$$
$$(3 \;\&\; 6) \text{ or } (4 \;\&\; 2) \text{ or } (1 \;\&\; 5)$$

As the equation of the first degree has one compound root and the equation of the second degree has four compound roots and the equation of the third degree has nine compound roots so the equation of the Nth degree has N^2 compound roots.

A more comprehensive discussion of the quadratic equation and its four compound roots is given in a monograph BIFOLIATE NUMBERS.

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Out of Doors, A Guide to Nature, by Paul B. Mann, Associate in Education, American Museum of Natural History, and Head of Department of Biology, Evander Childs High School, New York City; and George T. Hastings, Faculty Member of Nature Camp, Pennsylvania State College, and Head of Department of Biology, Theodore Roosevelt High School, New York City. 458 pp. Adequately illustrated with working diagrams, excellent reproductions of original photographs and of a few borrowed photographs, and line drawings. Henry Holt and Company.

As the title suggests, this is a guide to physical and biological field study. While the book is elementary in its treatment of nature study, it is suitable for use in nature study classes with students of a wide range of ages. The book is especially valuable for use in camps and in connection with the work of high school classes in science. The scope of the book is indicated by the four section headings,—Getting Acquainted with Animal Life, Getting Acquainted with Plant Life, Getting Acquainted with Earth and Sky, and Getting Acquainted with Nature in Camp. The concluding chapter of the book describes and lists equipment desirable for nature study in class or camp work. Appendix A describes systems of classification of plants and animals and Appendix B furnishes excellent brief keys for the summer and winter study of trees.

J. C. I.

Nature Guiding on Wheels, by William G. Vinal, School of Education, Western Reserve University, Cleveland, O. and by Teachers of Elementary Science, Western Reserve University. Papers. Manuscript form. 114 pages, Published under the authority of the School of Education, Western Reserve University, 1936. Price 75 cents.

These manuscripts are the result of a three weeks bus trip by Professor Vinal and twenty-five teachers of the School of Education to New York and New England. The various teachermembers of the company chose topics for special observation and study. Each of the teachers then prepared a paper on the subject chosen. The various papers compose this book under the editorship of Professor Vinal.

The papers, or chapters, show much keen and intelligent observation by the various authors. They also show much study and thought. They should be of value as a source book of Nature Study and a guide for any desiring to follow the itinerary of this group through New York and New England.

W. Whitney

Nature Games, by William G. Vinal, Nature Guide School, Western Reserve University, Cleveland, Ohio. Pamphlet, 32 pages. Published by W. F. Humphrey Press, Inc., Geneva, New York. Price 10 cents.

This phamphlet is designed to be a source book of aids in nature study teaching. There are 85 games described on various aspects of nature such as birds, trees, etc. The games are well thought out and should be of much help in familiarizing children and students with natural objects. There is also a key to the identification of trees in winter by feeling and smell. The pamphlet should be of much value to nature study teachers.

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The Nature Guide's Dictionary, by William G. Vinal, Nature Guide School, Western Reserve University, Cleveland, Ohio. Pamphlet, 17 pages. Published by W. F. Humphrey Press, Geneva, New York, 1936. Price 10 cents.

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W. WHITNEY

Tree Flowers of Forest, Park, and Street. By Walter E. Rogers, Professor of Botany in Lawrence College, with drawings from nature by Olga A. Smith, Instructor in Botany in Lawrence College. Binding Blue Terek Homespun, silver embossed cover design by Olga Smith, size 20 × 26 cm. Pages 500, illustrations many, consisting of full page plates, silhouettes and marginal drawings. Published by the author, Appleton, Wisconsin, 1935.

This is a book which will delight lovers of trees. It is a sumptuous book throughout. Paper, printing, binding, and illustrations are all special for this book.

As the author says, trees are not well known, especially as flowering plants, outside of habitual observers and students of trees, even to the idea held by some that some trees do not bear flowers. This is because the majority of tree flowers are small and inconspicuous. So the author's aim has been to remedy this failure to fully appreciate trees by a book of Tree Flowers. The text therefore is largely a background or explanations to render the figures more understandable. It is chiefly a pictorial book of trees. Full scientific descriptions of trees may be readily obtained from other sources.

The plates are largely photographic many times enlarged—first by the camera and then still further enlarged in the process of half toning. To correct any erroneous impressions as to the real size of the flowers. There are life size drawings of the flowers at the top of the title pages.

The author notes correctly that the true characteristics of trees are better displayed in winter when there is no foliage to obscure. So with each tree there are one or several silhouettes of the tree in its various aspects. The entire work on the book has been done very carefully and painstakingly. This reviewer very heartily recommends it to tree students.

W. Whitney

Descriptive Chemistry, by Sherman R. Wilson, Head of the Exact Science Department, Northwestern High School, Detroit, Michigan. First edition, pp. vii+312. 1.9×14.5×20.3 cm. 177 Figures, and frontispiece. Cloth, 1936, $1.20. Henry Holt and Co., N. Y.

This book has the merit of not being too lengthy; although it contains plenty of material for a half year course. It is frankly descriptive and informational and not primarily designed to train pupils in scientific thinking. It is to be used in a lecture-demonstration course for general students in the hope that, while they may not learn much of the science of chemistry they may learn a lot about chemistry. To quote the author from his preface, "There are no valences and formulas to be taught, no problems to be solved, no equations to balance and no college entrance to be met. The teacher is free." While this may remind some of the "new deal," nevertheless a good time will doubtless be had by all.

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Plane and Spherical Trigonometry, by H. L. Rietz, Professor of Mathematics, University of Iowa; J. F. Reilly, Professor of Mathematics, University of Iowa; and Roscoe Woods, Associate Professor of Mathematics, University of Iowa. Revised Edition. Cloth. Pages xi+168+72+xiii. 14×21.5 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

This text presents the usual subject matter of a first course in Plane Trigonometry and a brief introduction to Spherical Trigonometry. New ideas are introduced one at a time. Numerous examples are given to fix each new concept in the student's mind before another is introduced. The presentation of the subject is not marred by the introduction of new or radical ideas, i.e., at least to this critic the book appears to be an honest effort on the part of the authors to present the material common to all good texts in Trigonometry in a logical and constructive manner, and in accordance with generally accepted methods of teaching the subject.

In particular the authors are to be praised for their careful explanation of the following topics; reporting and computing with approximations, the degree of accuracy to be expected, statements of formulas in words, checking of numerical solutions by use of Newton's formulas, and investigation of the range of values for which inverse trigonometric identities hold.

As a result of the authors' plan of introducing one new idea at a time, radiant measure is not introduced until Chapter X, inverse trigonometric functions until Chapter XI, and equations until Chapter XII. This allows very little time for the student to become familiar with these important topics. The first eight fundamental identities are proved by means of special triangles, which may or may not appeal to all trigonometry instructors.

This text is undoubtedly far better than the average and should therefore enjoy a wide use.

JOHN J. CORLISS

LINER USES BEAM RADIO TO "SEE" THROUGH FOG

Little mentioned and still in experimental use on the S.S. Normandie are ultra-short radio wave devices which can detect fog-obscured obstacles in the path of the vessel up to a distance of four and a half miles.

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